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(54) **BLACK MATRIX BASE BOARD AND MANUFACTURING METHOD THEREFOR, AND LIQUID CRYSTAL DISPLAY PANEL AND MANUFACTURING METHOD THEREFOR.**

(57) A black matrix base board comprising a transparent base board and a light interrupting layer formed thereon, containing metallic particles and thereby having a high light interrupting capability and a low reflection factor. This black matrix base board is used as the flat display of a liquid crystal display panel, etc., the imager of a CCD, etc., or the color sensor, etc. The liquid crystal panel configured by sealing liquid crystal between the two black matrix base boards which face each other exhibits a remarkable contrast, because semiconductor driving elements on one of the base boards are provided with the light shielding layer containing metallic particles. The elements are protected effectively.

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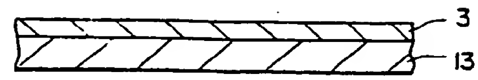
F I G.4 (A)



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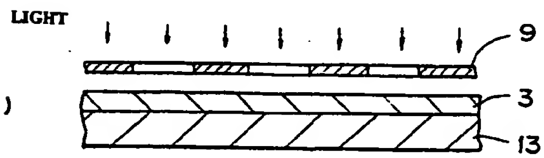

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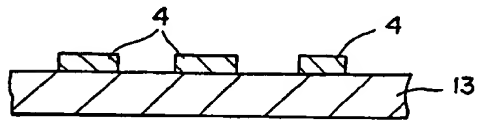

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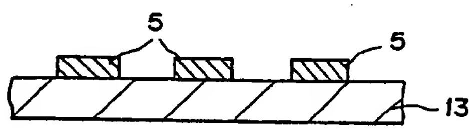

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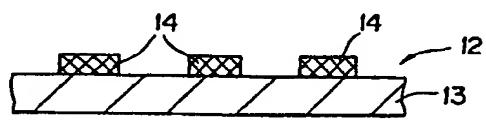

The present invention relates to black matrix substrates and processes for preparing the same, more particularly to black matrix substrates which show high dimensional accuracy and excellent light-shielding properties and processes for preparing the same. Further, the invention also relates to liquid crystal display panels and processes for preparing the same, more particularly to liquid crystal display panels of high precision which can be easily prepared.

Monochromatic or colour liquid crystal display panels have been recently paid much attention as flat displays. The liquid crystal display panels include those of active matrix system and those of simple matrix system. In the colour liquid crystal display panels of both systems, a colour filter is used. For example, a colour liquid crystal display panel of active matrix system using a thin film transistor (TFT) is formed by placing a TFT substrate and a colour filter to face each other and sealing a liquid crystal layer between a substrate of the TFT substrate and a substrate of the colour filter. For the colour filter, three primaries of red (R), green (G) and blue (B) are used, and the liquid crystal acts as a shutter by switching on or off an electrode corresponding to each pixel of R, G and B, whereby transmission of each light of the three primaries is controlled to effect color display. On the other hand, the TFT substrate comprises a transparent substrate, a semiconductor device and a pixel electrode, said semiconductor device and said pixel electrode being formed integrally with each other on the transparent substrate. The semiconductor device is a thin film transistor (TFT) composed of a gate electrode, a gate insulating layer, a semiconductor layer made of amorphous silicon (a-Si) or the like, a source electrode and a drain electrode. One end of the drain electrode is connected with the semiconductor layer, and the other end thereof is connected with the pixel electrode. Further, an alignment film is formed to cover the semiconductor device and the pixel electrode.

In the semiconductor layer made of a-Si or the like, however, an photocurrent is large, and therefor the semiconductor device is required to be shielded from light to inhibit leaking of the photocurrent. Accordingly, the color filter is constructed by forming a light-shielding layer (black matrix), colored layers of R, G and B, a overcoat, a transparent electrode layer and an orientation layer on a transparent substrate. The light-shielding layer also serves to enhance chromaticness and display contrast in addition to the inhibition of leaking of the photocurrent. Such a light-shielding layer as mentioned above is required to be provided not only in the color liquid crystal display panels but also in the monochromatic liquid crystal display panels for the same reason.

As the light-shielding layer, there have been conventionally known a light-shielding layer obtained by forming a relief through photoetching of a chromium thin film, a light-shielding layer obtained by dyeing a hydrophilic resin relief, a light-shielding layer obtained by forming a relief using a photosensitive resin in which a black pigment is dispersed (see: Japanese Patent Laid-Open Publications No. 1(1989)-102429, No. 1(1989)-239523 and No. 2(1990)-239204), a light-shielding layer obtained by electrodeposition of a black electrodeposition paint, a light-shielding layer obtained by metal-plating with a given pattern on a cured polymer film containing a catalyst for electroless plating to form a metallic thin film (see: Japanese Patent Laid-Open Publication No. 2(1990)-251801), and a light-shielding layer obtained by printing.

However, there are various problems in those conventional light-shielding layers. For example, the light-shielding layer obtained by forming a relief through photoetching of a chromium thin film needs a vacuum process such as deposition or sputtering in its preparation, or the process for preparing the light-shielding layer is complicated, resulting in high production cost, though the layer shows high dimensional accuracy. Further, in this light-shielding layer, a reflectance of chromium is necessarily restrained to enhance the display contrast under an intense external light, and therefore it is necessary to further conduct sputtering of chromium having a low reflectance, resulting in much higher production cost. The light-shielding layer obtained by using a photosensitive resin in which a black dye or a black pigment is dispersed, though the production cost of this layer is low, has such problems that a photo process becomes unstable and satisfactory light-shielding properties can be hardly obtained because the photosensitive resin is black, whereby black matrix of high quality cannot be obtained. The light-shielding layer obtained by forming a metallic thin film through electroless plating has a problem of high reflectance because metal is deposited only on a surface of the curable film.

In the process for preparing a liquid crystal display panel, the light-shielding layer is required to be formed with extremely high accuracy from the viewpoint of alignment of the light-shielding layer and the semiconductor device on the TFT substrate, and this alignment operation is also required to be made with high accuracy. Therefore, yields of the liquid crystal display panels are compelled to be reduced in the conventional process. For shielding the semiconductor device from light much more effectively, a method of enlarging a width of the light-shielding layer can be mentioned. However, this method still has a problem. That is, if the width of the light-shielding layer is enlarged, an aperture ratio of the resulting liquid crystal display panel becomes small, and thereby brightness of the panel is reduced.

To solve the above-mentioned problems, a method of forming a light-shielding layer directly on the semiconductor device of the TFT substrate is carried out (see: Japanese Patent Laid-Open Publication No. 60(2985)-184228). Even by the use of this method, however, there has not been obtained yet a liquid crystal display panel having a light-shielding layer which shows a high optical density, a low reflectance and a high dimensional accuracy and which can be easily prepared without using a vacuum process.

It is an object of the present invention to provide a black matrix substrate employable for a flat display such as a liquid crystal display panel, an imager such as CCD or a color filter of such as a color sensor and showing a high dimensional accuracy, excellent light-shielding properties and a low reflectance, and a process by which such a black matrix substrate as mentioned above can be prepared at a low cost.

It is another object of the invention to provide a color or monochromatic liquid crystal display panel in which display can be effected with high precision and high contrast and which can be easily prepared, and a process for preparing such a color or monochromatic liquid crystal display panel as mentioned above.

The black matrix substrate according to the invention has a structure comprising a transparent substrate and a light-shielding layer provided on the transparent substrate, and the light-shielding layer contains metallic particles inside thereof, whereby the light-shielding layer shows excellent light-shielding properties and has a low reflectance.

In first aspect the present invention provides a black matrix substrate comprising a transparent substrate and a light-shielding layer containing metallic particles inside thereof which is provided on the transparent substrate.

A first method of preparing a black matrix substrate in accordance with the invention comprises the steps of exposing to light a photosensitive resin layer containing a hydrophilic resin, said photosensitive resin layer being formed on a transparent substrate, through a photo mask having a pattern for a black matrix, developing the photosensitive resin layer to form a relief on the transparent substrate, immersing the transparent substrate in an aqueous solution of a metallic compound serving as a catalyst for electroless plating, washing with water and drying the transparent substrate, and then bringing the relief on the transparent substrate into contact with an electroless plating solution to form a light-shielding layer having a pattern for a black matrix.

A second method of preparing a black matrix substrate in accordance with the invention comprises the steps of exposing to light a photosensitive resin layer containing a hydrophilic resin and a metallic compound serving as a catalyst for electroless plating, said photosensitive resin layer being formed on a transparent substrate, through a photo mask having a pattern for a black matrix, developing the photosensitive resin layer, washing with water and drying the transparent substrate to form a relief on the transparent substrate, and then bringing the relief on the transparent substrate into contact with an electroless plating solution to form a light-shielding layer having a pattern for a black matrix.

A third method of preparing a black matrix substrate in accordance with the invention comprises the steps of forming on a transparent substrate a photosensitive resin layer containing a compound having at least one of a diazo group and an azido group, a metallic compound serving as a catalyst for electroless plating and a hydrophilic resin, exposing the resist layer to light through a photo mask having a pattern for a black matrix, and bringing the resist layer into contact with an electroless plating solution to form a light-shielding layer having a pattern for a black matrix.

The black matrix substrate obtained by the above processes has a light-shielding layer (black matrix) containing a metal inside thereof, and this black matrix has a high optical density, a low reflectance and a high dimensional accuracy. Accordingly, the black matrix substrate can be used for a colour filter showing high reliability and high contrast. Further, since the black matrix substrate can be prepared without conducting a vacuum process, the production costs can be lowered.

In a second aspect the invention provides a liquid crystal display panel comprising substrates facing each other and a liquid crystal sealed between the substrates, and at least one of the substrates is provided with a semiconductor device having a light-shielding layer containing metallic particles inside thereof. Owing to this structure, shielding of the semiconductor device from light can be secured by the light-shielding layer, and brightness of the display panel can be enhanced.

A first method of preparing the liquid crystal display panel in accordance with the invention comprises the steps of forming a photosensitive resin layer containing a hydrophilic resin on a semiconductor device side of the substrate provided with the semiconductor device, exposing to light the photosensitive resin layer through a photo mask having a pattern for a black matrix, developing the photosensitive resin layer to form a relief on the semiconductor device, immersing the substrate in an aqueous solution of a metallic compound serving as a catalyst for electroless plating, washing with water and drying the substrate, and then bringing the relief into contact with an electroless plating solution to form a light-shielding layer having a pattern for a black matrix on the semiconductor device.

A second method of preparing a liquid crystal display panel in accordance with the invention comprises the steps of forming a photosensitive resin layer containing a hydrophilic resin and a metallic compound serving as a catalyst for electroless plating on a semiconductor device side of the substrate provided with the semiconductor device, exposing to light the photosensitive resin layer through a photo mask having a pattern for a black matrix, developing the photosensitive resin layer, washing with water and drying the substrate to form a relief on the semiconductor device, and then bringing the relief into contact with an electroless plating solution to form a light-shielding layer having a pattern for a black matrix on the semiconductor device.

In the liquid crystal display panel obtained by the above processes of the invention, the semiconductor device formed on the substrate is per se provided with a light-shielding layer, and this light-shielding layer contains metallic particles inside thereof. Therefore, the light-shielding layer shows a high optical density and a low reflectance, whereby shielding of the semiconductor device from light can be secured without enlarging a width of the light-shielding layer differently from the conventional case, and the aperture ratio can be increased. Further, an alignment operation of the semiconductor device and the other substrate can be easily made, and the semiconductor device can be stably driven.

The invention will now be described in detail with reference to the accompanying drawings in which:-

Figure 1 is a perspective view showing an active matrix liquid crystal display in accordance with the first aspect of the invention,

Figure 2 is a schematic sectional view of the liquid crystal display shown in Figure 1,

Figure 3 is an enlarged partial sectional view of a colour filter used for the liquid crystal display shown in Figure 1,

Figure 4 is a series of sectional views illustrating the steps of a first process for preparing a black matrix substrate in accordance with the invention,

Figure 5 is a series of sectional views illustrating the steps of a second process for preparing a black matrix substrate in accordance with the invention,

Figure 6 is a series of sectional views illustrating the steps of a third process for preparing a black matrix substrate in accordance with the invention,

Figure 7 is a series of sectional views illustrating the steps of a fourth process for preparing a black matrix substrate in accordance with the invention,

Figure 8 is a perspective view showing a colour liquid crystal display panel including black matrix in accordance with the second aspect of the invention,

Figure 9 is a schematic sectional view of the colour liquid crystal display panel shown in Figure 8 and

Figure 10 is a schematic sectional view of a second colour liquid crystal display panel in accordance with the second aspect of the invention.

In Figures 1 and 2, the liquid crystal display (LCD) is constructed by placing a colour filter 10 and a transparent glass substrate 20 to face each other by way of a sealing material 30, forming therebetween a liquid crystal layer 40 made of twisted nematic (TN) liquid crystal and having a thickness of about 5 to 10 μm, and arranging polarising films 50 and 51 on the outer sides of the colour filter 10 and the transparent glass substrate 20 respectively.

Figure 3 is an enlarged partial sectional view of the colour filter 10. In Figure 3, the colour filter 10 includes a black matrix substrate 12 composed of a transparent substrate 13 and a light-shielding layer (black matrix) 14 formed on the substrate 13, a colored layer 16 formed among the black matrix 14 of the black matrix substrate 12, a overcoat 18 provided to cover the black matrix 14 and the colored layer 16, and a transparent electrode 19. This color filter 10 is arranged so that the transparent electrode 19 is positioned on the side of the liquid crystal layer 40. The colored layer 16 consists of a red pattern 16R, a green pattern 16G and a blue pattern 16B, and the arrangement of those color patterns is mosaic arrangement as shown in FIG. 1. The arrangement of the color patterns is in no way limited to the mosaic arrangement, and other arrangements such as triangle arrangement and stripe arrangement are available.

On the transparent glass substrate 20, display electrodes 22 are provided correspondingly to each color patterns 16R, 16G and 16B, and each of the display electrodes 22 has a thin film transistor (TFT) 24. Further, among the display electrodes 22 are laid a scanning line (gate bus line) 26a and a data line 26b correspondingly to the black matrix 14.

In such LCD 1 as mentioned above, each of the color patterns 16R, 16G and 16B constitutes a pixel. When the display electrode corresponding to each pixel is switched on or off under irradiation with light from the side of the polarizing film 51, the liquid crystal layer 40 acts as a shutter and the light is transmitted by each pixels of the color patterns 16R, 16G and 16B to effect color display.

Examples of materials employable for the transparent substrate 13 of the black matrix substrate 12 constituting the color filter 10 include rigid materials having no flexibility such as quartz glass, low-expanded

glass and soda-lime glass, and flexible materials having flexibility such as transparent resin film and optical resin plate. Among various materials, a 7059 glass (available from Corning Corporation) is particularly suitable for a color filter used for LCD of active matrix system, because it has a small coefficient of thermal expansion and is excellent in dimensional stability and workability in a high temperature heating treatment and further it is a non-alkali glass containing no alkali component.

A first process for preparing the black matrix substrate 12 according to the invention is now described with reference to Figure 4.

In the first place, a photosensitive resin containing a hydrophilic resin is applied onto the transparent substrate 13 to form a photosensitive resin layer 3 having a thickness of 0.1 to 5.0 µm, preferably 0.1 to 2.0 µm (FIG. 4A). When the thickness of the photosensitive resin layer is less than 0.1 µm, deposition of metallic particles becomes insufficient, and hence a light-shielding layer having a satisfactory optical density cannot been obtained. When the thickness thereof exceeds 5.0 µm, a resolution is reduced. The thickness of the photosensitive resin layer is more preferably not more than 2.0 µm from the viewpoint of the surface roughness. In the next place, the photosensitive resin layer 3 is exposed to light through a photo mask 9 for a black matrix (FIG. 4B). Then, thus exposed photosensitive resin layer 3 is developed to form a relief having a pattern for a black matrix (FIG. 4C). Thereafter, the transparent substrate 13 is immersed in an aqueous solution of a metallic compound serving as a catalyst for electroless plating, followed by washing with water and drying. The substrate is then subjected to a heat treatment (100 to 200 °C, 5 to 30 minutes) to make the above relief a catalyst-containing relief 5 (FIG. 4D). The catalyst-containing relief 5 on the transparent substrate 13 is brought into contact with an electroless plating solution to make the catalyst-containing relief a light-shielding layer, whereby a black matrix 14 is formed (FIG. 4E).

In the process for preparing a black matrix substrate according to the invention, it is possible that after formation of the above-mentioned relief 4 (FIG. 4C), the transparent substrate is subjected to a heat treatment (70 to 150 °C, 5 to 30 minutes) and then immersed in an aqueous solution of a metallic compound serving as a catalyst for electroless plating, followed by washing with water and drying, to form a catalyst-containing relief 5 (FIG. 4D). In this case, it is preferred to further conduct a heat treatment (150 to 250 °C, 30 minutes to 2 hours) after the black matrix 14 is formed by electroless plating (FIG. 4E). By conducting the heat treatment before the formation of the catalyst-containing relief 5 as described above, the relief 4 can be uniformly dried, and the aqueous solution of a metallic compound serving as a catalyst for electroless plating permeates uniformly into the relief 4. Further, a period of time required for the electroless plating can be controlled by adjusting conditions of the heat treatment. Accordingly, metal particles deposit almost uniformly within the whole of the catalyst-containing relief 5, and hence the resulting black matrix 14 is almost free from lifting, peeling off, etc.

A second process for preparing the black matrix substrate 12 according to the invention is now described below referring to FIG. 5. In the first place, a photosensitive resin containing a hydrophilic resin and an aqueous solution of a metallic compound serving as a catalyst for electroless plating is applied onto the transparent substrate 13 to form a photosensitive resin layer 7 having a thickness of about 0.1 to 5.0 µm, preferably about 0.1 to 2.0 µm (FIG. 5A). In the next place, the photosensitive resin layer 7 is exposed to light through a photo mask 9 for a black matrix (FIG. 5B). Then, thus exposed photosensitive resin layer is developed and dried to form a catalyst-containing relief 8 having a pattern for a black matrix (FIG. 5C). Thereafter, a heat treatment (70 to 150 °C, 5 to 30 minutes) may be carried out. Then, the catalyst-containing relief 8 on the transparent substrate 13 is brought into contact with an electroless plating solution to make the catalyst-containing relief a light-shielding layer, whereby a black matrix 14 is formed (FIG. 5D). Thereafter, it is preferred to conduct a heat treatment (150 to 250 °C, 30 minutes to 2 hours).

The photosensitive resins employable in the invention are resists imparted with light sensitivity. Such resists can be obtained, for example, by adding compounds or resins having a cross-rinkable photosensitive function groups to hydrophilic resins. Examples of the hydrophilic resins include natural proteins (e.g., gelatin, casein, glue and egg albumin), carboxymethyl cellulose, polyvinyl alcohol, polyacrylic acid, polyacrylamide, polyvinyl pyrrolidone, polyethylene oxide, maleic anhydride copolymers, carboxylic acid modified products of the above resins, and sulfonic acid modified products of the above resins. These hydrophilic resins can be used singly or in combination. Examples of the compounds or resins having a cross-rinkable photosensitive function group include diazonium compounds having diazo group, diazo resins which are reaction products of diazonium compounds and paraformaldehyde, azido compounds having azido group, cinnamic acid condensation resin obtained by condensation of cinnamic acid with polyvinyl alcohol, resin using stilbazolium salt, and ammonium bichromate. As a matter of course, the light-sensitive groups employable for the invention are in no way limited to the above-mentioned cross-rinkable photosensitive function groups. Since the photosensitive resin contains a hydrophilic resin as described above, the electroless plating solution easily permeates into the catalyst-containing relief 5, 8 when the catalyst-

containing relief is brought into contact with the electroless plating solution, and metallic particles uniformly deposit within the catalyst-containing relief. Accordingly, the resulting black matrix 14 becomes sufficiently black and has a low reflectance, and as a result, the aforementioned problem of reflection by a metal layer associated with the conventional technique of formation of a chromium thin film can be solved.

Examples of the metallic compound serving as a catalyst for electroless plating in the invention include water-soluble salts such as chlorides and nitrates of various metals (e.g., palladium, gold, silver, platinum and copper), and complex compounds of those metals. In the use of the metallic compound, commercially available activators for electroless plating can be per se employed. When such metallic compound is incorporated into the photosensitive resin as described above, the metallic compound is used preferably in an amount of about 0.00001 to 0.001 % by weight.

The electroless plating solutions employable in the invention are those containing a reductant, a water-soluble heavy metal salt capable of being reduced, a basic compound to enhance plating speed, reducing efficiency, etc., a pH adjusting agent such as inorganic or organic acid, a buffering agent, a complexing agent to stabilize heavy metal ion, an accelerator, a stabilizer, a surface active agent, etc. Concrete examples of the reductant include hypophosphorous acid, sodium hypophosphite, sodium boron hydride, N-dimethylamine borane, borazine derivative, hydrazine and formalin. Concrete examples of the water soluble heavy metal salts include nickel, cobalt, iron, copper and chromium. Examples of the basic compounds include caustic soda and ammonium hydroxide. Examples of the buffering agents include alkali salts of oxycarboxylic acid (e.g., sodium citrate and sodium acetate), boric acid, carbonic acid, organic acid and inorganic acid. The electroless plating solutions may be used in combination of two or more kinds. For example, it is possible to use first an electroless plating solution containing a boron type reductant capable of easily forming a nucleus (e.g., palladium nucleus in the case of using a palladium compound as the metallic compound serving as a catalyst for electroless plating), for example, sodium boron hydride, and then to use an electroless plating solution containing a hypophosphorous acid type reductant which is fast in the metal deposition speed.

In the case of using an electroless plating solution containing a boron type reductant, a temperature of the electroless plating solution in the electroless plating stage is preferably in the range of about 10 to 60 °C. When the temperature of the electroless plating solution exceeds 60 °C, the plating speed becomes too high, and thereby the light-shielding layer sometimes suffer metallic gloss.

A third process for preparing the black matrix substrate 12 according to the invention is described below referring to Figure 6.

In the first place, a photosensitive resin containing a hydrophilic resin, a compound having diazo group or azido group and a metallic compound serving as a catalyst for electroless plating is applied onto the transparent substrate 13 and dried, to form a photosensitive resin layer 3 having a thickness of about 0.1 to 5.0 μm, preferably about 0.1 to 2.0 μm (FIG. 6A). It is well known that the compound having diazo group or azido group functions to inhibit plating in the stage of electroless plating, and that when a resist containing this compound, a hydrophilic resin and a compound serving as a catalyst for electroless plating is subjected to pattern exposure and then brought into contact with an electroless plating solution, metallic particles are formed within the resist layer by the electroless plating to form a light-shielding layer (see: Japanese Patent Laid-Open Publications No. 57(1982)-104928 and No. 57(1982)-104929). In the next place, the photosensitive resin layer 3 is exposed to light through a photo mask 9 for a black matrix (FIG. 6B). Then, the transparent substrate 13 is brought into contact with an electroless plating solution to deposit metallic particles in the exposed portion by electroless plating, whereby a light-shielding layer (Black matrix) is formed (FIG. 6C).

A fourth process for preparing the black matrix substrate 12 is illustrated below referring to Figure 7.

In the first place, a photosensitive resin containing a hydrophilic resin, a compound having diazo group or azido group and a metallic compound serving as a catalyst for electroless plating is applied onto the transparent substrate 13 and dried, to form a photosensitive resin layer 3 having a thickness of about 0.1 to 5.0 μm, preferably about 0.1 to 2.0 μm (FIG. 7A). In the next place, the photosensitive resin layer 3 is exposed to light through a photo mask 9 for a black matrix (FIG. 7B). Then, the transparent substrate 13 is brought into contact with an electroless plating solution to deposit metallic particles in the exposed portion by electroless plating, whereby a light-shielding layer is formed (FIG. 7C). Thereafter, the transparent substrate 13 is developed to remove the unexposed portion, whereby a black matrix 14 is formed (FIG. 7D).

Examples of hydrophilic resins used for preparing such a black matrix substrate as shown in FIG. 6 or FIG. 7 include natural high molecular materials such as gelatin, casein, glue, gum arabic, shellac and egg albumin, carboxymethyl cellulose, polyvinyl alcohol (including partially saponified polyvinyl acetate and modified polyvinyl alcohol), polyacrylic acid, polyacrylamide, polyvinyl pyrrolidone, polyethylene oxide, maleic anhydride copolymers, carboxylic acid modified products of the above resins, and sulfonic acid

modified products of the above resins. Other resins than the above-exemplified ones are also employable with the proviso that they are water-soluble or hydrophilic. The hydrophilic resin used in the invention has such a hydrophilic degree that the electroless plating solution permeates into the photosensitive resin layer 3. The hydrophilic resins can be used in combination of plural kinds.

The compound having diazo group or azido group used for the purpose of inhibiting the electroless plating include the following compounds.

Examples of the compounds having diazo group preferably used include p-N,N-diethylaminobenzenediazonium chloride zinc chloride double salt, p-N-ethyl-N-β-hydroxyethylaminobenzenediazonium chloride zinc chloride double salt, p-N, N-dimethylaminobenzenediazonium chloride zinc chloride double salt, 4-morpholinobenzenediazonium chloride zinc chloride double salt, 4-morpholino-2,5-diethoxybenzenediazonium chloride zinc chloride double salt, 4-morpholino-2,5-dibutoxybenzenediazonium chloride zinc chloride double salt, 4-benzoylamino-2,5-diethoxybenzenediazonium chloride zinc chloride double salt, 4-(4-methoxybenzoylamino)-2,5-diethoxybenzenediazonium chloride zinc chloride double salt, 4-(p-toluylmercapto)-2,5-dimethoxybenzenediazonium chloride zinc chloride double salt, 4-diazodiphenylamine zinc chloride double salt, 4-diazo-4'-methoxydiphenylamine zinc chloride double salt, 4-diazo-3-methoxydiphenylamine zinc chloride double salt, sulfates, phosphates and boron fluoride salts corresponding to the above-mentioned zinc chloride double salts, and diazo resins which are reaction products of these diazonium compounds and paraformaldehyde.

Examples of the compounds having azido group include p-azidobenzalaldehyde, p-azidoacetophenone, p-azidobenzoic acid, p-azidobenzalacetophenone, p-azidobenzalacetone, 4,4'-diazidochalcone, 2,6-bis-(4'-azidobenzal)-acetone, 4,4'-diazidostilbene-2,2'-disulfonic acid, p-azidobenzoyl chloride, 3-azidophthalic anhydride, 4,4'-diazidodiphenylsulfone, p-azidocinnamic acid, and 4,4'-diazidobenzoylacetone-2,2'-sodiumsulfonate.

As the metallic compound and the electroless plating solution used herein, the above-exemplified metallic compounds and electroless plating solutions can be employed.

Examples of the developing solutions used for removing the unexposed portion (other portion than the black matrix pattern) after the formation of the light-shielding layer for a black matrix include water, warm water, and inorganic or organic alkali such as NaOH, KOH, Na_2CO_3, tetramethylammonium hydroxide and choline. They can be used in accordance with a conventional manner.

In any of the processes for preparing a black matrix substrate mentioned above, a reflectance of the obtained light-shielding layer at a wavelength of 545 nm is at most 30 %, generally not more than 5 %. This reflectance is extremely lower than a reflectance (50 to 80 %) of a conventional light-shielding layer made of chromium thin film, and therefore display quality of very high level can be obtained.

The metallic particles dispersed within the light-shielding layer have a particle diameter of at most 0.05 µm, generally in the range of 0.01 to 0.02 µm, and owing to the metallic particles, the light-shielding layer is a uniform and homogeneous film.

Further, in any of the aforesaid processes for preparing a black matrix substrate, a light-shielding layer having an optical density of not less than 3.0 can be obtained by varying the plating time, but the optical density of the light-shielding layer is preferably not less than 1.5 from the viewpoints of the aforementioned light-shielding properties against the TFT and improvement of contrast. When the optical density of the light-shielding layer is less than 1.5, the light-shielding layer does not have a sufficient light-shielding function, and the obtained substrate cannot be used as a black matrix substrate.

A thickness of the light-shielding layer can also be optionally determined by varying the amount of the photosensitive resin to be applied, but the thickness thereof is generally in the range of 0.1 to 5.0 µm, preferably 0.1 to 2.0 µm, from the viewpoints of the aforementioned surface roughness, resolution and optical density of the resulting black matrix substrate.

The colored layers of R, G and B can be formed on circumferences of the black matrix 14 of the black matrix substrate 12 (i.e., areas other than the black matrix 14 on the transparent substrate 13 in the embodiments shown in FIGS. 4, 5 and 7, and the unexposed portion of the photosensitive resin layer in the embodiment shown in FIG. 6) by conventionally known methods such as dyeing method, dispersing method, printing method and electrodeposition. These methods may be used in combination.

The overcoat 18 provided to cover the black matrix 14 and the colored layer 16 of the color filter 10 is for the purpose of improving surface roughness, enhancing reliability and preventing contamination, of the color filter 10. The overcoat 18 can be formed using transparent resins such as acrylic resins, epoxy resins and polyimide resins or transparent inorganic compounds such as silicon dioxide. A thickness of the overcoat 18 is preferably in the range of about 0.1 to 10 µm.

An indium tin oxide (ITO) film can be used as the transparent electrode 19. The ITO film can be formed by a conventional method such as deposition or sputtering. A thickness of the ITO film is preferably in the

range of about 200 to 2,000 Å.

A liquid crystal display panel in accordance with the second aspect of the invention is described below with reference to Figures 8 to 10. The colour liquid crystal panel 101 shown in Figures 8 and 9 is constructed by placing a TFT substrate 110 and a colour filter 130 to face each other by way of a sealing material (not shown), sealing a liquid crystal layer 140 made of a twisted nematic (TN) liquid crystal and having a thickness of about 5 to 10 μm between a substrate of the TFT substrate and a substrate of the colour filter, and arranging polarising films 150 and 151 on outer sides of the colour filter 130 and the TFT substrate 110, respectively.

The TFT substrate includes a transparent substrate 111, a semiconductor device 112 and pixel electrodes 120, said semiconductor device and said pixel electrodes being formed integrally with each other on the transparent substrate. Each of the pixel electrodes 120 is provided correspondingly to each color pattern of the color filter 130 which will be described later, and among the pixel electrodes 120 is laid a scanning line (gate bus line) 123a and a data line 123b. The semiconductor device 112 is a thin film transistor (TFT) composed of a gate electrode 113, a gate insulating layer 114, a semiconductor layer 115 made of amorphous silicon (a-Si) or the like, a source electrode 116 and a drain electrode 117. One end of the drain electrode 117 is connected with the semiconductor layer 115, and the other end thereof is connected with the pixel electrode 120. On the source electrode 116 and the drain electrode 117 of the semiconductor device 112 is formed a light-shielding layer 119 so that the semiconductor layer 115 is shielded from light. Further, an orientation layer 125 is formed to cover the semiconductor device 112 and the pixel electrodes 120.

The color filter 130 includes a transparent substrate 131, a colored layer 132 formed on the transparent substrate 131, a overcoat 133 formed to cover the colored layer 132, a transparent electrode 134 and an orientation layer 135. This color filter 130 is arranged so that the orientation layer 135 is positioned on the side of the liquid crystal layer 140. The colored layer 132 is composed of a red pattern 132R, a green pattern 132G and a blue pattern 132B, and the arrangement of those color patterns is mosaic arrangement as shown in FIG. 8. The arrangement of the color patterns is in no way limited to the mosaic arrangement, and other arrangements such as triangle arrangement and stripe arrangement are also available.

In such a color liquid crystal display panel 101 as mentioned above, each of the color patterns 132R, 132G and 132B constitutes a pixel. When the pixel electrode 120 corresponding to each pixel is switched on or off under irradiation with light from the side of the polarizing film 151, the liquid crystal layer 140 acts as a shutter and the light is transmitted by each pixels of the color patterns 132R, 132G and 132B to effect color display.

Examples of materials employable for the transparent substrates 111 and 131 constituting TFT substrate 110 and the color filter 130, respectively, include rigid materials having no flexibility such as quartz glass, low-expanded glass and soda-lime glass, and flexible materials having flexibility such as transparent resin film and optical resin plate. Among various materials, a 7059 glass (available from Corning Corporation) is particularly suitable for the color liquid crystal display panel of active matrix system, because it has a small coefficient of thermal expansion and is excellent in dimensional stability and workability in a high temperature heating treatment, and further it is a non-alkali glass containing no alkali component.

The semiconductor device 112 (TFT) composed of the gate electrode 113, the gate insulating layer 114, the semiconductor layer 115, the source electrode 116 and the drain electrode 117 can be formed by conventionally known methods.

The light-shielding layer 119 provided on the source electrode 116 and the drain electrode 117 to shield the semiconductor layer 115 of the semiconductor device 112 from light is formed, for example, by the following process including electroless plating. That is, the whole surface of the transparent substrate 111 including the semiconductor layer 115, the source electrode 116 and the drain electrode 117 is coated with a photosensitive resin containing a hydrophilic resin to form a photosensitive resin layer having a thickness of about 0.1 to 5.0 μm, preferably about 0.1 to 2.0 μm. Then, the photosensitive resin layer is exposed to light through a photo mask for a light-shielding layer 119. After the exposure, the photosensitive resin layer is developed to form a relief having a pattern for a light-shielding layer on the pre-determined areas of the source electrode 116 and the drain electrode 117. Thereafter, the transparent substrate 111 is immersed in an aqueous solution of a metallic compound serving as a catalyst for electroless plating, then washed with water, dried, and subjected to a heat treatment (50 to 200 °C, 5 to 30 minutes), to form a catalyst-containing relief. The transparent substrate 111 is further immersed in an electroless plating solution to bring the catalyst-containing relief into contact with the electroless plating solution, whereby metallic particles deposit inside of the relief. Thus, a light-shielding layer 119 was formed.

A process for preparing the liquid crystal display panel in accordance with the second aspect of the invention is as follows. The catalyst-containing relief is formed by a process comprising forming a relief as described above, then conducting a heat treatment (70 to 150°C, 5 to 30 minutes), immersing the transparent substrate 111 in an aqueous solution of a metallic compound serving as a catalyst for electroless plating, washing with water and drying the substrate. In this case, it is preferred to further conduct a heat treatment (150 to 250°C, 30 minutes to 2 hours) after the light-shielding layer 119 is formed by electroless plating. By conducting the heat treatment before the formation of the catalyst-containing relief as described above, the relief can be uniformly dried, and the aqueous solution of a metallic compound serving as a catalyst for electroless plating uniformly permeates into the relief. Further, a period of time required for the electroless plating can be controlled by adjusting conditions of the heat treatment. Accordingly, metal particles deposit almost uniformly within the whole of the catalyst-containing relief, and thereby the resulting light-shielding layer 119 is almost free from lifting, peeling off, etc.

The light-shielding layer 119 may be also formed by the following process including electroless plating. That is, a photosensitive resin containing a hydrophilic resin and an aqueous solution of a metallic compound serving as a catalyst for electroless plating is applied onto the transparent substrate 111, to form a photosensitive resin layer having a thickness of about 0.1 to 5μm, preferably about 0.1 to 2.0 μm. Then, the photosensitive resin layer is exposed to light through a photo mask for a light-shielding layer 119, and thus exposed photosensitive resin layer is developed and dried to form a catalyst-containing relief having a pattern for a light-shielding layer. Thereafter, a heat treatment (70 to 150 °C, 5 to 30 minutes) may be carried out. Then, the transparent substrate 111 is immersed in an electroless plating solution to bring the catalyst-containing relief into contact with the electroless plating solution, whereby metallic particles deposit inside of the catalyst-containing relief. Thus, a light-shielding layer 119 was formed.

As the photosensitive resin and the hydrophilic resin to be contained in the photosensitive resin, there can be employed those described before in the process for preparing a black matrix substrate, and concrete examples thereof are omitted herein.

In a case where the light-shielding layer 119 is formed from a metal layer of chromium thin film or the like, leakage of current takes place between the source electrode 116 and the drain electrode 117. If an insulating layer is provided between the light-shielding layer 119 and the electrode in order to prevent the leakage of current, a condenser is formed, so that provision of such insulating layer is unfavourable. In the present invention, however, the light-shielding layer is formed by depositing metallic particles inside of the catalyst-containing relief by electroless plating as described above, so that the light-shielding layer has sufficiently high specific resistance.

The colour liquid crystal display panel shown in Figure 10 is the same as the colour liquid crystal display panel shown in Figure 9 except that the light-shielding layer 119 is provided by way of an insulating layer 118. In Figures 9 and 10, the same numerals designate corresponding parts to each other.

The insulating layer 118 of the colour liquid crystal display panel shown in Figure 10 can be formed from known insulating materials such as SiN_x. Owing to the insulating layer 118, the semiconductor device 112 is effectively isolated from the light-shielding layer 119, and thereby contamination of the semiconductor layer 115 caused by the light-shielding layer 119 and leakage of current between the source electrode 116 and the drain electrode 117 can be surely prevented.

The light-shielding layer 119 can be formed on the source electrode 116 and the drain electrode 117 so as to cover the semiconductor layer 115 of the semiconductor device 112 by way of the insulating layer 118 in accordance with the aforementioned method for forming the light-shielding layer, so that detailed description on the formation of the light-shielding layer 119 is omitted herein.

As the metallic compound serving as a catalyst for electroless plating and the electroless plating solution, there can be employed those described before in the process for preparing a black matrix substrate, and concrete examples thereof are omitted herein.

In such a color filter 130 as mentioned above, the colored layer 132 composed of a red pattern 132R, a green pattern 132G and a blue pattern 132B can be formed by conventionally known methods such as dyeing method, dispersing method, printing method and electrodeposition.

The overcoat 133 provided to cover the colored layer 132 of the color filter 130 is for the purpose of improving surface roughness of the color filter 130, enhancing reliability thereof and preventing contamination of the liquid crystal layer 140. The overcoat 133 can be formed using transparent resins such as acrylic resins, epoxy resins and polyimide resins, melamine resin or transparent inorganic compounds such as silicon dioxide. A thickness of the overcoat is preferably in the range of 0.1 to 10 μm.

An indium tin oxide (ITO) film can be used as the transparent electrode 134 in Figure 9 or Figure 10. The ITO film can be formed by a conventional method such as sputtering. A thickness of the ITO film is preferably in the range of 200 to 2,000 A.

As the orientation layer 125 of the TFT substrate 110 and the orientation layer 135 of the colour filter 130, there can be used those formed by known methods such as a layer formed by oblique deposition, a layer formed by application of an organic orientating agent having cyano group, carboxylic group or the like, or a layer made of polyimide resin.

The present invention is described in more detail by way of the following examples.

EXAMPLE 1

Sample 1

A 7059 glass (available from Corning Corporation, thickness: 1.1 mm) was used as a transparent substrate. Onto the transparent substrate was applied a photosensitive resin having the following composition by means of spin coating (rotation speed: 800 r.p.m.), and the photosensitive resin was dried at 70 °C for 5 minutes to form a photosensitive resin layer (thickness: 2 µm).

(Composition of the photosensitive resin)

.A 10% aqueous solution of polyvinyl alcohol (Gosenal T-330, available from Nippon Gosei Kagaku K.K.)	20 parts by weight
.A 20% aqueous solution of diazo resin (D-OII, available from Shinko Giken K.K.)	0.8 part by weight
.Water	15 parts by weight

Then, the photosensitive resin layer was exposed to light through a photo mask for a black matrix (line width: 20 µm). In the exposure, an ultra-high-pressure mercury lamp (2 kW) was used as a light source, and irradiation with the light was carried out for 10 seconds. Thereafter, the photosensitive resin layer was subjected to spray development using water of a normal temperature and then subjected to air drying, to form a relief having a line width of 20 µm.

Subsequently, the transparent substrate was immersed in an aqueous solution of palladium chloride (Red Sumer, available from Nippon Kanigen K.K.) for 10 seconds, then washed with water and dried. The transparent substrate was then subjected to a heat treatment at 150 °C for 15 minutes to make the above relief a catalyst-containing relief.

Thereafter, the transparent substrate was immersed in a nickel plating solution of 30 °C containing a boron type reductant (Top Chemialloy B-1, nickel plating solution available from Okuno Seiyaku K.K.) for 3 minutes, then washed with water and dried to form a light-shielding layer (black matrix). Thus, a black matrix substrate (Sample 1) was obtained.

Samples 2 - 4

The above procedure for preparing Sample 1 was repeated except for varying the thickness of the photosensitive resin layer to 1 µm, 4 µm and 10 µm, to prepare black matrix substrates (Samples 2 to 4).

Sample 5

Onto the same transparent substrate as used for Sample 1, a photosensitive resin having the following composition was applied by means of spin coating (rotation speed: 800 r.p.m.), and the photosensitive resin was dried at 70 °C for 5 minutes to form a photosensitive resin layer (thickness: 2 µm).

(Composition of the photosensitive resin)

• A 10% aqueous solution of polyvinyl alcohol (Gosenal T-330, available from Nippon Gosei Kagaku K.K.)	20 parts by weight
• A 20% aqueous solution of diazo resin (D-011, available from Shinko Giken K.K.)	0.8 part by weight
• An aqueous solution of palladium chloride (Red Sumer, available from Nippon Kanigen K.K.)	15 parts by weight

Then, the photosensitive resin layer was exposed to light through a photo mask for a black matrix (line width: 20 µm). In the exposure, an ultra-high-pressure mercury lamp (2 kw) was used as a light source, and irradiation with the light was carried out for 10 seconds. Thereafter, the photosensitive resin layer was subjected to spray development using water of a normal temperature and then subjected to air drying, to form a catalyst-containing relief having a line width of 20 µm.

Subsequently, the transparent substrate was immersed in a nickel plating solution of 30 °C containing a boron type reductant (Top Chemialloy B-1, nickel plating solution available from Okuno Seiyaku K.K.) for 20 seconds, and then further immersed in a nickel plating solution of 30 °C containing a hypophosphorous acid type reductant (Tsp55 Nickel, nickel plating solution available from Okuno Seiyaku K.K., A/C = 1/2) for 2 minutes. The transparent substrate was washed with water and dried to form a light-shielding layer (black matrix). Further, the transparent substrate was subjected to a heat treatment at 200 °C for 1 hour to obtain a black matrix substrate (Sample 5).

Samples 6 - 8

The above procedure for preparing Sample 5 was repeated except for varying the thickness of the photosensitive resin layer to 1 µm, 4 µm and 10 µm, to prepare black matrix substrates (Samples 6 to 8).

Comparative Sample 1

A 7059 glass (available from Corning Corporation, thickness: 1.1 mm) was used as a transparent substrate. This substrate was immersed in a hydrogen fluoride acid to conduct etching of the glass. Thus, a pre-treatment of the surface of the substrate was carried out. Then, tin ion was adsorbed on the surface of the substrate using stannous chloride and a hydrochloric acid. Thereafter, the substrate was subjected to the same palladium chloride treatment and the same electroless nickel plating as those for Sample 1, and then a black matrix substrate (Comparative Sample 1) was obtained in accordance with a conventional process.

Comparative Sample 2

Onto the same transparent substrate as used for Sample 1, a photosensitive resin having the following composition was applied by means of spin coating (rotation speed: 200 r.p.m.), and the photosensitive resin was dried to form a photosensitive resin layer (thickness: 1 µm).

(Composition of the photosensitive resin)

• A 10 % aqueous solution of gelatin	10 parts by weight
• A 10 % aqueous solution of ammonium bichromate	3 parts by weight

Then, the photosensitive resin layer was exposed to light through a photo mask for a black matrix (line width: 20 µm). In the exposure, an ultra-high-pressure mercury lamp (2 kw) was used as a light source, and irradiation with the light was carried out for 10 seconds. Thereafter, the photosensitive resin layer was subjected to spray development using water of a normal temperature and then subjected to air drying, to form a relief for a black matrix having a line width of 20 µm.

Subsequently, the transparent substrate was immersed in a 1 % stannous chloride solution (1N hydrochloric acid acidic solution) of 60 to 70 °C for 60 to 120 seconds, then further immersed in a 0.3 % palladium chloride solution (1N hydrochloric acid acidic solution) at 30 °C for 30 to 60 seconds, and washed with water. Immediately after washing with water, the transparent substrate was immersed in a nickel plating solution (Blue Sumer, available from Nippon Kanigen K.K.) of 70 to 80 °C and electroless plating was tried to be made. However, nickel deposited not only in the relief but also in the whole of the substrate because tin was attached onto all surface of the substrate, so that it was impossible to form a black matrix.

Each of the black matrix substrates obtained as above (Samples 1 to 8, Comparative Samples 1 and 2) was measured on an optical density OD of the black matrix, a reflectance R thereof at a wavelength of 545 nm, a resolution thereof (line and space) and particle diameters of the nickel particles. The results obtained by the measurements are set forth in Table 1.

Table 1

Black Matrix Substrate	Optical Density OD	Reflectance R (%)	Resolution (μm)	Diameter of Nickel Particle (μm)
Sample 1	OD ≥ 3.0	R ≤ 5	4	0.01-0.02
Sample 2	OD ≥ 3.0	R ≤ 5	4	0.01-0.02
Sample 3	OD ≥ 3.0	R ≤ 5	6	0.01-0.02
Sample 4	OD ≥ 3.0	R ≤ 5	12	0.01-0.02
Sample 5	OD ≥ 3.0	R ≤ 5	4	0.01-0.02
Sample 6	OD ≥ 3.0	R ≤ 5	4	0.01-0.02
Sample 7	OD ≥ 3.0	R ≤ 5	5	0.01-0.02
Sample 8	OD ≥ 3.0	R ≤ 5	10	0.01-0.02
Comp. Sample 1	OD ≥ 3.0	R ≥ 50	4	
Comp. Sample 2	OD ≥ 3.0	R ≥ 50	unable to be plated	

EXAMPLE 2

Sample 1

Formation of a photosensitive resin layer and exposure of the photosensitive resin layer to light were made in the same manner as those for Sample 1 of Experiment Example 1. Then, the photosensitive resin layer was subjected to spray development using water of a normal temperature, and further subjected to a heat treatment at 100 °C for 30 minutes to form a relief for a black matrix having a line width of 20 μm.

Subsequently, the transparent substrate was immersed in an aqueous solution of palladium chloride (Red Sumer, available from Nippon Kanigen K.K.) for 10 seconds, then washed with water and dried, to make the above relief a catalyst-containing relief.

Thereafter, the transparent substrate was immersed in a nickel plating solution of 30 °C containing a boron type reductant (Top Chemialloy B-1, nickel plating solution available from Okuno Seiyaku K.K.) for 3 minutes, then washed with water and dried to form a light-shielding layer (black matrix). The transparent substrate was then subjected to a heat treatment at 200 °C for 1 hour to obtain a black matrix substrate (Sample 1).

Samples 2 - 4

The above procedure for preparing Sample 1 was repeated except for varying the thickness of the photosensitive resin layer to 1 μm, 4 μm and 10 μm, to prepare black matrix substrates (Samples 2 to 4).

Each of the black matrix substrates obtained as above (Samples 1 to 4) was measured on an optical density OD of the black matrix, a reflectance R thereof at a wavelength of 545 nm, a resolution thereof (line and space) and particle diameters of nickel particles in the same manner as described in Experiment Example 1. The results obtained by the measurements are set forth in Table 2.

Table 2

Black Matrix Substrate	Optical Density OD	Reflectance R (%)	Resolution (μm)	Diameter of Nickel Particle (μ)
Sample 1	OD ≥ 3.0	R ≤ 5	4	0.01-0.02
Sample 2	OD ≥ 3.0	R ≤ 5	4	0.01-0.02
Sample 3	OD ≥ 3.0	R ≤ 5	6	0.01-0.02
Sample 4	OD ≥ 3.0	R ≤ 5	12	0.01-0.02

EXAMPLE 3

Sample 1

A 7059 glass (available from Corning Corporation, thickness: 1.1 mm) was used as a transparent substrate. Onto the transparent substrate was applied a photosensitive resin having the following composition by means of spin coating (rotation speed: 600 r.p.m.), and the photosensitive resin was dried at 70 °C for 10 minutes to form a photosensitive resin layer (thickness: 3 μm).

(Composition of the photosensitive resin)

• A 10 % aqueous solution of polyvinyl alcohol (Gosenal T-330, available from Nippon Gosei Kagaku K.K.)	20 parts by weight
• A hydrochloric aqueous solution of palladium chloride (Red Sumer, available from Nippon Kanigen K.K.)	15 parts by weight
• A 20 % aqueous solution of diazo resin (D-011, available from Shinko Giken K.K.)	0.8 part by weight

Then, the photosensitive resin layer was exposed to light through a photo mask for a black matrix (negative pattern, line width: 20 μm). In the exposure, an ultra-high-pressure mercury lamp (2 kw) was used as a light source, and irradiation with the light was carried out for 20 seconds.

Subsequently, the transparent substrate was immersed in a nickel plating solution of a normal temperature containing a boron type reductant (Top Chemialloy B-1, available from Okuno Seiyaku K.K.) for 30 seconds, and then further immersed in a nickel plating solution of a normal temperature containing a hypophosphorous acid type reductant (Tsp55 Nickel, available from Okuno Seiyaku K.K., A/C = 1/2) for 1 minute to deposit nickel particles in the exposed portion, whereby a light-shielding layer was formed. The transparent substrate was washed with water and dried to obtain a black matrix substrate.

In the black matrix substrate, the black matrix had an optical density (OD) of not less than 3.0 and a reflectance of not more than 5 % at a wavelength of 545 nm. Further, as results of measurements of a resolution (line and space) of the black matrix and a mean particle diameter of the deposited nickel particles, the resolution was 4 μm and the mean particle diameter was in the range of 0.01 to 0.02 μm.

Sample 2

Onto the same transparent substrate as used for Sample 1, a photosensitive resin having the following composition was applied by means of spin coating (rotation speed: 800 r.p.m.), and the photosensitive resin was dried at 70 °C for 10 minutes to form a photosensitive resin layer (thickness: 2 μm).

(Composition of the photosensitive resin)

• A 10 % aqueous solution of polyvinyl alcohol (Gosenal T-330, available from Nippon Gosei Kagaku K.K.)	20 parts by weight
• A hydrochloric aqueous solution of palladium chloride	15 parts by weight
• A 10 % methyl cellosolve solution of diazo monomer (DH-300BF$_4$, available from Daito Kagaku K.K.)	2.0 parts by weight
• A 20 % aqueous solution of diazo resin (D-011, available from Shinko Giken K.K.)	0.2 part by weight

Then, the photosensitive resin layer was exposed to light through a photo mask for a black matrix (negative pattern, line width: 20 µm). In the exposure, an ultra-high-pressure mercury lamp (2 kw) was used as a light source, and irradiation with the light was carried out for 30 seconds.

Subsequently, the transparent substrate was immersed in a nickel plating solution of a normal temperature containing a boron type reductant (Top Chemialloy B-1, available from Okuno Seiyaku K.K.) for 10 seconds, and then further immersed in a nickel plating solution of a normal temperature containing a hypophosphorous acid type reductant (Tsp55 Nickel, available from Okuno Seiyaku K.K., A/C = 1/2) for 60 seconds to deposit nickel particles in the exposed portion, whereby a light-shielding layer was formed. The transparent substrate was washed with water and dried.

Further, the photosensitive resin layer was developed using warm water of 60 °C to remove the unexposed portion of the photosensitive resin layer and remain only the light-shielding layer. Thus, a black matrix substrate was obtained.

In the black matrix substrate, the black matrix had an optical density (OD) of not less than 3.0 and a reflectance of not more than 5% at a wavelength of 545 nm. Further, the resolution of the black matrix (line and space) was 4 µm and the diameters of the nickel particles were in the range of 0.01 to 0.02 µm.

EXAMPLE 4

A 7059 glass (available from Corning Corporation, thickness: 1.1 mm) was used as a transparent substrate. On the pre-determined areas were formed a gate electrode and a pixel electrode using aluminum (A1). Then, a SiN_x layer as a gate insulating layer was formed so that the gate electrode was covered, and an amorphous silicon (a-Si) layer was formed on the gate electrode by way of the SiN_x layer. Further, an A1 source electrode is formed to be connected with one end of the a-Si layer, and an A1 drain electrode is formed to be connected with the other end of the a-Si layer and with the pixel electrode.

Subsequently, a photosensitive resin having the following composition was applied onto the transparent substrate by means of spin coating (rotation speed: 1,000 r.p.m.), and the photosensitive resin was dried at 70 °C for 5 minutes to form a photosensitive resin layer (thickness: 1.5 µm).

(Composition of the photosensitive resin)

• A 10 % aqueous solution of polyvinyl alcohol (Gosenal T-330, available from Nippon Gosei Kagaku K.K.)	20 parts by weight
• A 20 % aqueous solution of diazo resin (D-011, available from Shinko Giken K.K.)	0.8 part by weight
• Water	15 parts by weight

Then, the photosensitive resin layer was exposed to light through a photo mask for a light-shielding layer. In the exposure, an ultra-high-pressure mercury lamp (2 kw) was used as a light source, and irradiation with the light was carried out for 10 seconds. Thereafter, the photosensitive resin layer was subjected to spray development using water of a normal temperature and then subjected to air drying, to form a relief for a light-shielding layer having a line width of 1.0 µm on the pre-determined area including the a-Si layer, the source electrode and the drain electrode.

Subsequently, the transparent substrate was immersed in an aqueous solution of palladium chloride (Red Sumer, available from Nippon Kanigen K.K.) for 10 seconds, then washed with water and hydro-

extracted. The transparent substrate was then subjected to a heat treatment at 150 °C for 15 minutes to make the above relief a catalyst-containing relief.

The transparent substrate was then immersed in a nickel plating solution of 30 °C containing a boron type reductant (Top Chemialloy B-1, nickel plating solution available from Okuno Seiyaku K.K.) for 3 minutes, then washed with water and dried to form a light-shielding layer.

The light-shielding layer was measured on an optical density OD and a reflectance R at a wavelength of 545 nm. As a result, the optical density OD was not less than 3.0 and the reflectance R was not more than 5 %.

Further, a dilute solution of polyimide resin was applied onto the transparent substrate and dried to form an orientation layer (thickness: 0.05 µm). Thus, a TFT substrate was obtained.

Separately, a 7059 glass (available from Corning Corporation, thickness: 1.1 mm) was used as a transparent substrate, and colored layers of R, G and B were formed on the transparent substrate correspondingly to the above pixel electrodes in accordance with a known dyeing method.

Onto the colored layers, a dilute solution of acrylic resin was applied, and the solution was dried to form a heat-resistant overcoat. Further, a transparent electrode (ITO) was formed on the overcoat in accordance with a conventional manner. Then, a dilute solution of polyimide resin was applied onto the transparent electrode and dried to form an orientation layer (thickness: 0.05 µm). Thus, a color filter was obtained.

Using the TFT substrate and the color filter obtained as above, a color liquid crystal display panel of active matrix system was prepared. In this color liquid crystal display panel, the semiconductor device on the TFT substrate was effectively protected by the light-shielding layer, and the panel showed high brightness and high contrast because of its high aperture ratio.

EXAMPLE 5

On the pre-determined areas of a transparent substrate were formed a gate electrode, a pixel electrode, a gate insulating layer of a SiN_x layer, an amorphous silicon (a-Si) layer, an Al source electrode and an Al drain electrode in the same manner as described in Experiment Example 4. Then, on the transparent substrate was formed a photosensitive resin layer in the same manner as described in Experiment Example 4, and the photosensitive resin layer was exposed to light and developed. Thereafter, the transparent substrate was subjected to a heat treatment at 100 °C for 30 minutes to form a relief for a light-shielding layer having a line width of 1.0 µm on the pre-determined area including the a-Si layer, the source electrode and the drain electrode.

Subsequently, the transparent substrate was immersed in an aqueous solution of palladium chloride (Red Sumer, available from Nippon Kanigen K.K.) for 10 seconds, then washed with water and hydro-extracted to make the above relief a catalyst-containing relief.

The transparent substrate was then immersed in a nickel plating solution of 30 °C containing a boron type reductant (Top Chemialloy B-1, nickel plating solution available from Okuno Seiyaku K.K.) for 3 minutes, washed with water and dried to form a light-shielding layer. The transparent substrate was then subjected to a heat treatment at 200 °C for 1 hour.

The light-shielding layer was measured on an optical density OD and a reflectance R at a wavelength of 545 nm. As a result, the optical density OD was not less than 3.0 and the reflectance R was not more than 5 %.

Further, a dilute solution of polyimide resin was applied onto the transparent substrate and dried to form an orientation layer (thickness: 0.05 µm). Thus, a TFT substrate was obtained.

Using the TFT substrate obtained as above and the color filter obtained in Experiment Example 4, a color liquid crystal display panel of active matrix system was prepared in the same manner as described in Experiment Example 4. In this color liquid crystal display panel, the semiconductor device on the TFT substrate was effectively protected by the light-shielding layer, and the panel showed high brightness and high contrast because of its high aperture ratio.

EXAMPLE 6

The procedure for preparing the TFT substrate in Experiment Example 4 was repeated except for the light-shielding layer was formed by the process described below. That is, a photosensitive resin having the following composition was applied onto the transparent substrate on which a light-shielding layer would be provided by means of spin coating (rotation speed: 1,000 r.p.m.), and the photosensitive resin was dried at 70 °C for 5 minutes to form a photosensitive resin layer (thickness: 1.5 µm).

(Composition of the photosensitive resin)

• A 10 % aqueous solution of polyvinyl alcohol (Gosenal T-330, available from Nippon Gosei Kagaku K.K.)	20 parts by weight
• A 20 % aqueous solution of diazo resin (D-011, available from Shinko Giken K.K.)	0.8 part by weight
• An aqueous solution of palladium chloride (Red Sumer, available from Nippon Kanigen K.K.)	15 parts by weight

Then, the photosensitive resin layer was exposed to light through a photo mask for a light-shielding layer under the same conditions as those in Experiment Example 3. Thereafter, the photosensitive resin layer was subjected to spray development using water of a normal temperature, and subjected to air drying to form a catalyst-containing relief for a light-shielding layer having a line width of 1.0 μm.

Subsequently, the transparent substrate was immersed in a nickel plating solution of 30 °C containing a boron type reductant (Top Chemialloy B-1, nickel plating solution available from Okuno Seiyaku K.K.) for 20 seconds, and further immersed in a nickel plating solution of 30 °C containing a hypophosphorous acid type reductant (Tsp55 Nickel, nickel plating solution available from Okuno Seiyaku K.K., A/C = 1/2) for 2 minutes, then washed with water and dried to form a light-shielding layer. The transparent substrate was then subjected to a heat treatment at 200 °C for 1 hour.

The light-shielding layer was measured on an optical density OD and a reflectance R at a wavelength of 545 nm. As a result, the optical density OD was not less than 3.0 and the reflectance R was not more than 5 %.

Using the TFT substrate obtained as above and the color filter obtained in Experiment Example 4, a color liquid crystal display panel of active matrix system was prepared in the same manner as described in Experiment Example 4. In this color liquid crystal display panel, the semiconductor device on the TFT substrate was effectively protected by the light-shielding layer, and the panel showed high brightness and high contrast because of its high aperture ratio.

EXAMPLE 7

On the pre-determined areas of a transparent substrate were formed a gate electrode, a pixel electrode, a gate insulating layer of a SiN_x layer, an amorphous silicon (a-Si) layer, an Al source electrode and an Al drain electrode in the same manner as described in Experiment Example 4. Then, on the pre-determined area including the a-Si layer, the source electrode and the drain electrode was formed a SiN_x layer as an insulating layer. On the insulating layer was then formed a light-shielding layer in the same manner as described in Experiment Example 4.

Subsequently, using the TFT substrate obtained as above and the color filter obtained in Experiment Example 4, a color liquid crystal display panel of active matrix system was prepared in the same manner as described in Experiment Example 4. In this color liquid crystal display panel, the semiconductor device on the TFT substrate was effectively protected by the light-shielding layer, and the panel showed high brightness and high contrast because of its high aperture ratio.

The black matrix substrate of the present invention can be used for a flat display such as a liquid crystal display panel, an imager such as CCD, or a colour filter such as a colour sensor. The liquid crystal display panel of the present invention can be used as a flat display of high precision and high contrast.

Claims

1. A black matrix substrate comprising a transparent substrate and a light-shielding layer containing metallic particles inside thereof which is provided on the transparent substrate.

2. A black matrix substrate as claimed in Claim 1, wherein the light-shielding layer contains a hydrophilic resin.

3. A black matrix substrate as claimed in Claim 1 or Claim 2, wherein the light-shielding layer has a thickness in the range 0.1 to 5 μm, preferably in the range 0.1 to 2μm.

4. A black matrix substrate as claimed in any one of Claims 1 to 3, wherein the light-shielding layer has a reflectance of not more than 30%.

5. A black matrix substrate as claimed in any preceding claim, wherein the light-shielding layer has an optical density of not less than 1.5.

6. A black matrix substrate as claimed in any preceding claim, wherein the metallic particles contained in the light-shielding layer have particle diameters of not more than 0.05 µm.

7. A liquid crystal display panel comprising substrates facing each other and a liquid crystal sealed between the substrates, at least one of said substrates being provided with a semiconductor device having a light-shielding layer containing metallic particles inside thereof.

8. A liquid crystal display panel as claimed in Claim 7, wherein the light-shielding layer is provided on the semiconductor device by the medium of an insulating layer.

9. A liquid crystal display panel as claimed in Claim 7 or Claim 8, wherein the light-shielding layer has a thickness in the range 0.1 to 5 µm, preferably in the range 0.1 to 2 µm.

10. A liquid crystal display panel as claimed in any one of Claims 7, 8 or 9, wherein the light-shielding layer has a reflectance of not more than 30%.

11. A liquid crystal display panel as claimed in any one of Claims 7 to 10, wherein the light-shielding layer has an optical density of not less than 1.5.

12. A liquid crystal display panel as claimed in any one of Claims 7 to 11, wherein the metallic particles contained in the light-shielding layer have particle diameters of not more than 0.05 µm.

13. A process for preparing a black matrix substrate comprising the steps of exposing to light a photosensitive resin layer containing a hydrophilic resin, said photosensitive resin layer being formed on a transparent substrate, through a photo mask having a pattern for a black matrix, developing the photosensitive resin layer to form a relief on the transparent substrate, immersing the transparent substrate in an aqueous solution of a metallic compound serving as a catalyst for electroless plating, washing with water and drying the transparent substrate, and then bringing the relief on the transparent substrate into contact with an electroless plating solution to form a light-shielding layer having a pattern for a black matrix.

14. A process for preparing a black matrix substrate comprising the steps of exposing to light a photosensitive resin layer containing a hydrophilic resin and a metallic compound serving as a catalyst for electroless plating, said photosensitive resin layer being formed on a transparent substrate, through a photo mask having a pattern for a black matrix, developing the photosensitive resin layer, washing with water and drying the transparent substrate to form a relief on the transparent substrate, and then bringing the relief on the transparent substrate into contact with an electroless plating solution to form a light-shielding layer having a pattern for a black matrix.

15. A process for preparing a black matrix substrate comprising the steps of forming on a transparent substrate a photosensitive resin layer containing a compound having at least one of a diazo group and an azido group, a metallic compound serving as a catalyst for electroless plating and a hydrophilic resin, exposing the resist layer to light through a photo mask having a pattern for a black matrix, and bringing the resist layer into contact with an electroless plating solution to form a light-shielding layer having a pattern for a black matrix.

16. A process for preparing a black matrix substrate as claimed in Claim 15, said process further comprising developing an unexposed portion of the photosensitive resin layer to remove said portion after the formation of the light-shielding layer.

17. A process for preparing a liquid crystal display panel comprising substrates facing each other and a liquid crystal sealed between the substrates, at least one of said substrates being provided with a

semiconductor device, which comprises the steps of forming a photosensitive resin layer containing a hydrophilic resin on a semiconductor device side of the substrate provided with the semiconductor device, exposing to light the photosensitive resin layer through a photo mask having a pattern for a black matrix, developing the photosensitive resin layer to form a relief on the semiconductor device, immersing the substrate in an aqueous solution of a metallic compound serving as a catalyst for electroless plating, washing with water and drying the substrate, and then bringing the relief into contact with an electroless plating solution to form a light-shielding layer having a pattern for a black matrix on the semiconductor device.

18. A process for preparing a liquid crystal display panel comprising substrates facing each other and a liquid crystal sealed between the substrates, at least one of said substrates being provided with a semiconductor device, which comprises the steps of forming a photosensitive resin layer containing a hydrophilic resin and a metallic compound serving as a catalyst for electroless plating on a semiconductor device side of the substrate provided with the semiconductor device, exposing to light the photosensitive resin layer through a photo mask having a pattern for a black matrix, developing the photosensitive resin layer, washing with water and drying the substrate to form a relief on the semiconductor device, and then bringing the relief into contact with an electroless plating solution to form a light-shielding layer having a pattern for a black matrix on the semiconductor device.

19. A process as claimed in any one of Claims 13, 14, 15, 17 or 18, wherein the electroless plating solution is a plating solution containing nickel ion.

20. A process as claimed in any one of Claims 13, 14, 15, 17, 18 or 19, wherein the electroless plating solution is a nickel plating solution containing a boron hydride compound reductant.

21. A process as claimed in Claim 20, wherein the boron hydride compound reductant is dimethylamine borane.

22. An imaging device, colour filter or colour sensing device including a black matrix substrate as defined in any one of Claims 1 to 6.

F I G. 1

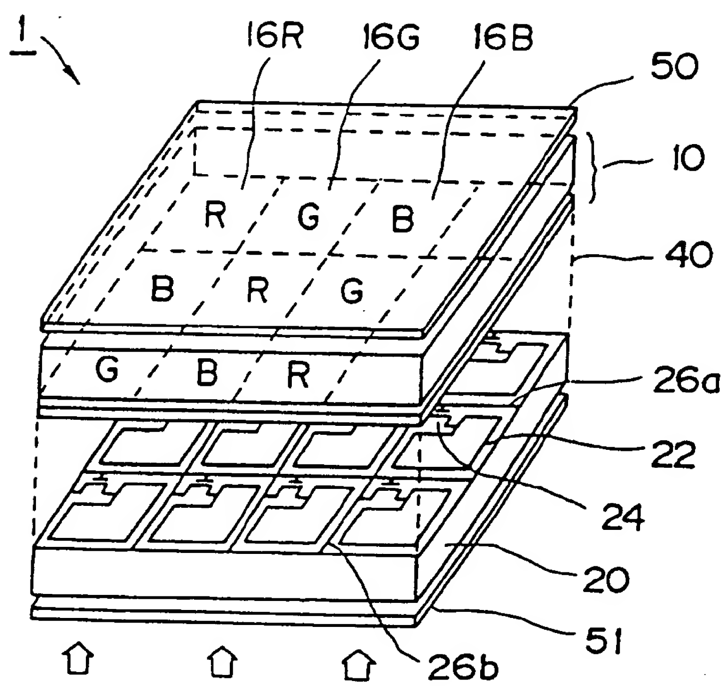

FIG. 2

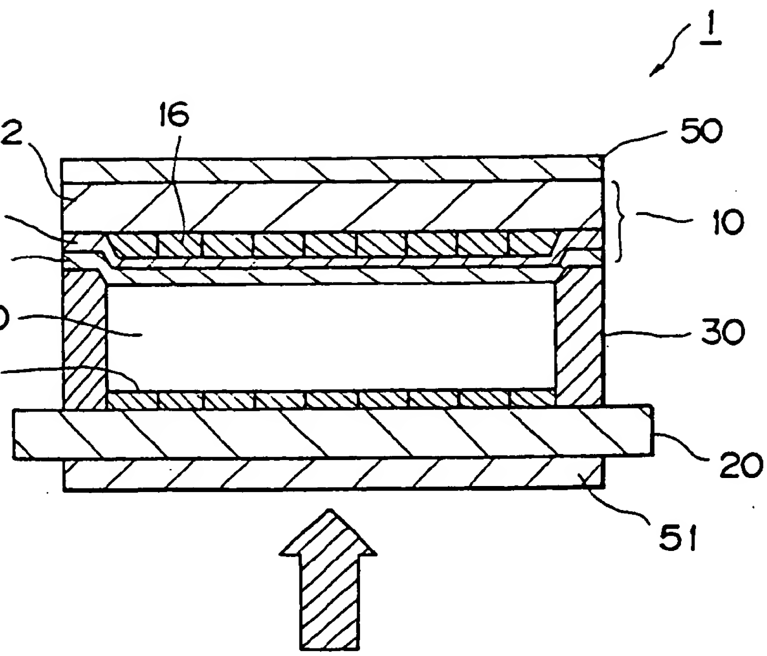
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FIG. 3

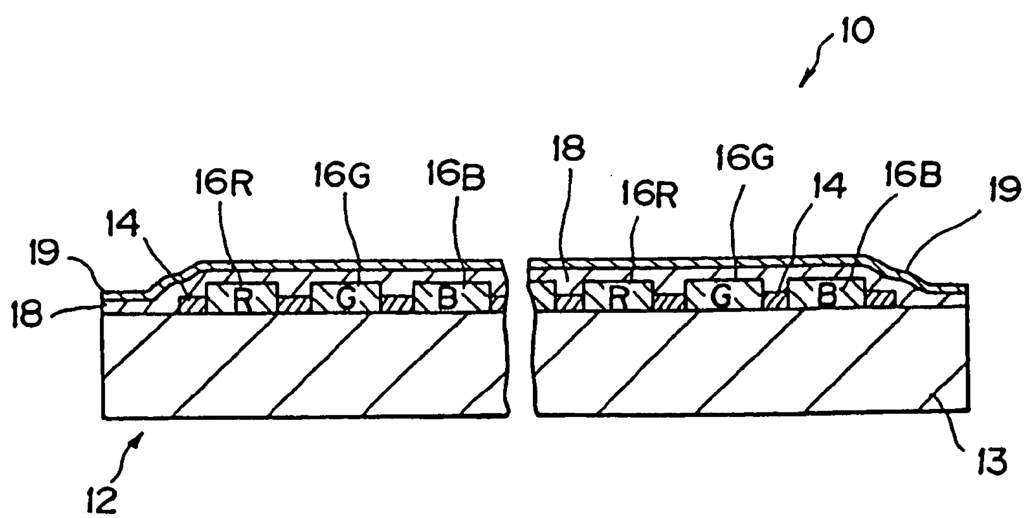
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FIG.4 (A)

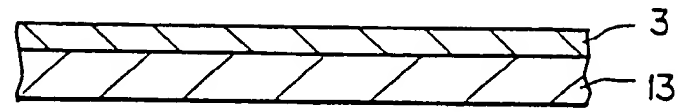


FIG.4 (B)

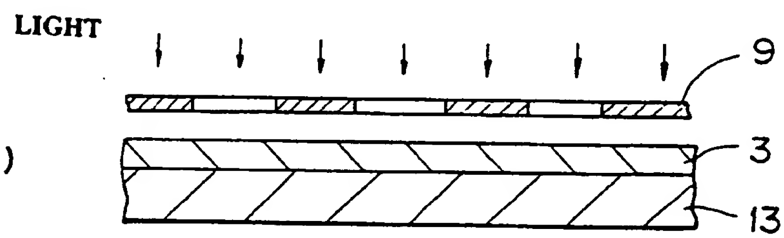


FIG.4 (C)

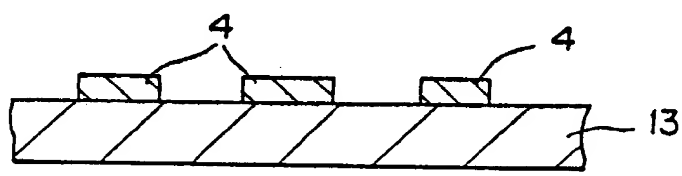


FIG.4 (D)

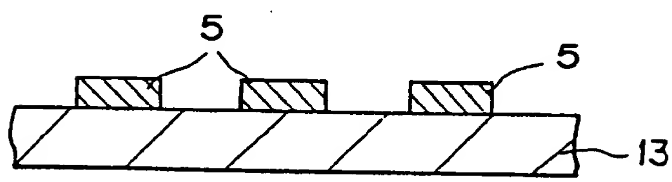


FIG.4 (E)

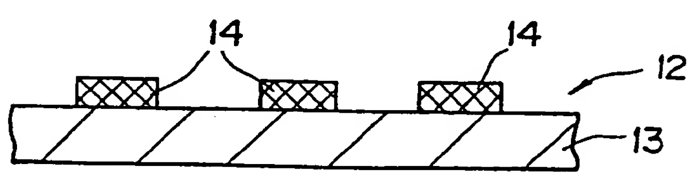


FIG. 5(A)

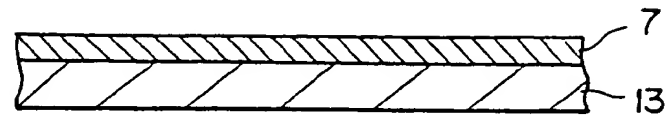


FIG. 5(B)

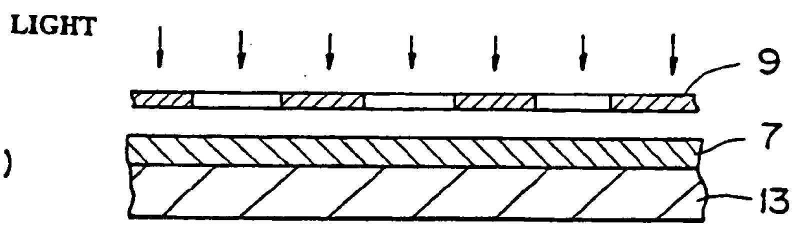


FIG. 5(C)

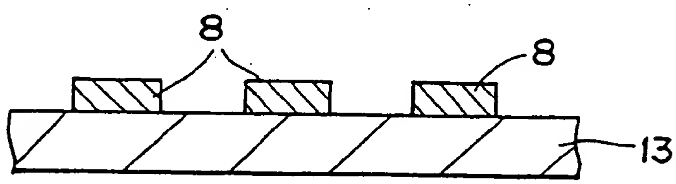


FIG. 5(D)

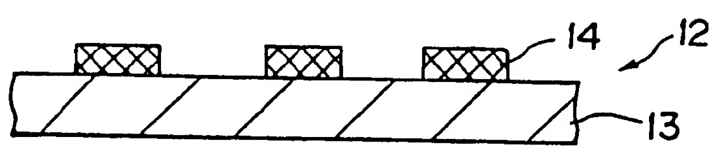


FIG.6 (A)

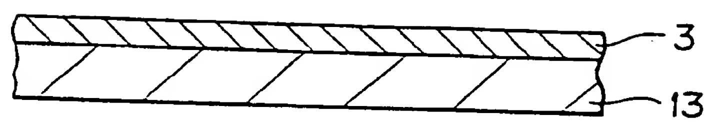


FIG.6 (B)

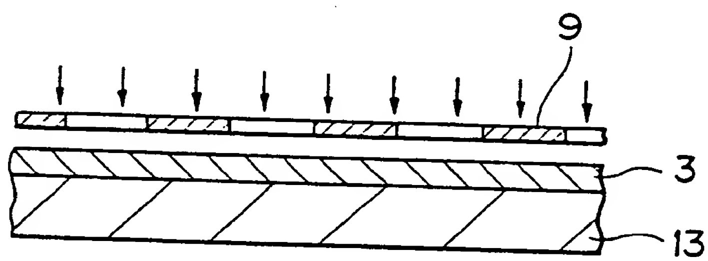


FIG.6 (C)

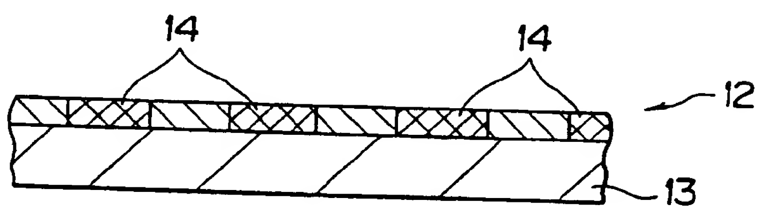


FIG. 7(A)

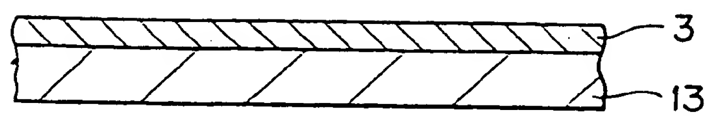


FIG. 7(B)

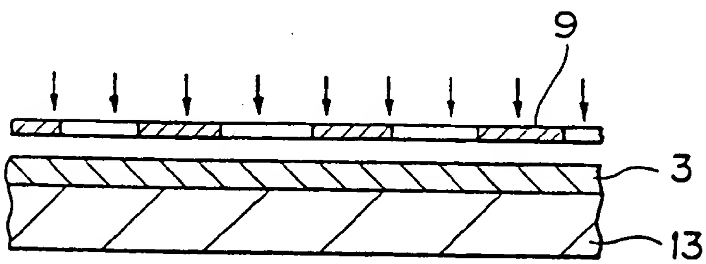


FIG. 7(C)

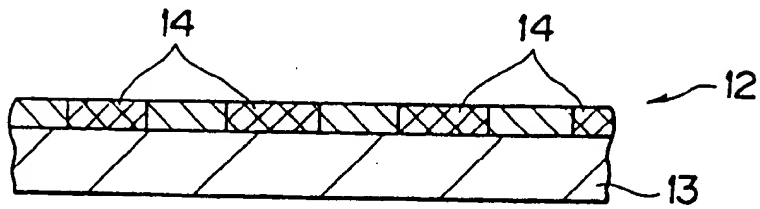


FIG. 7(D)

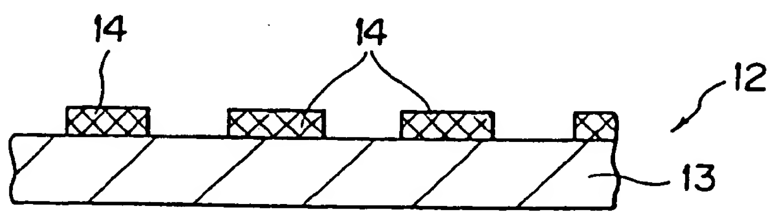
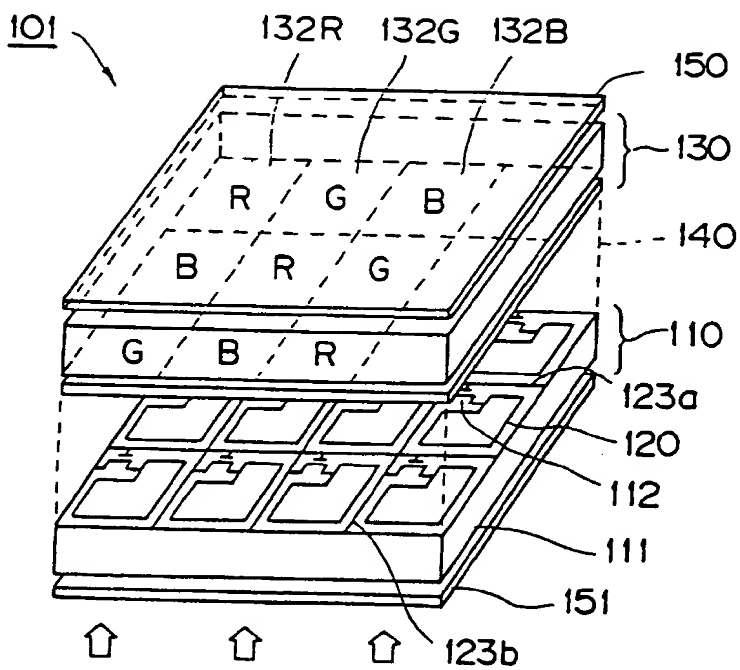


FIG. 8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R
G
B

FIG. 9

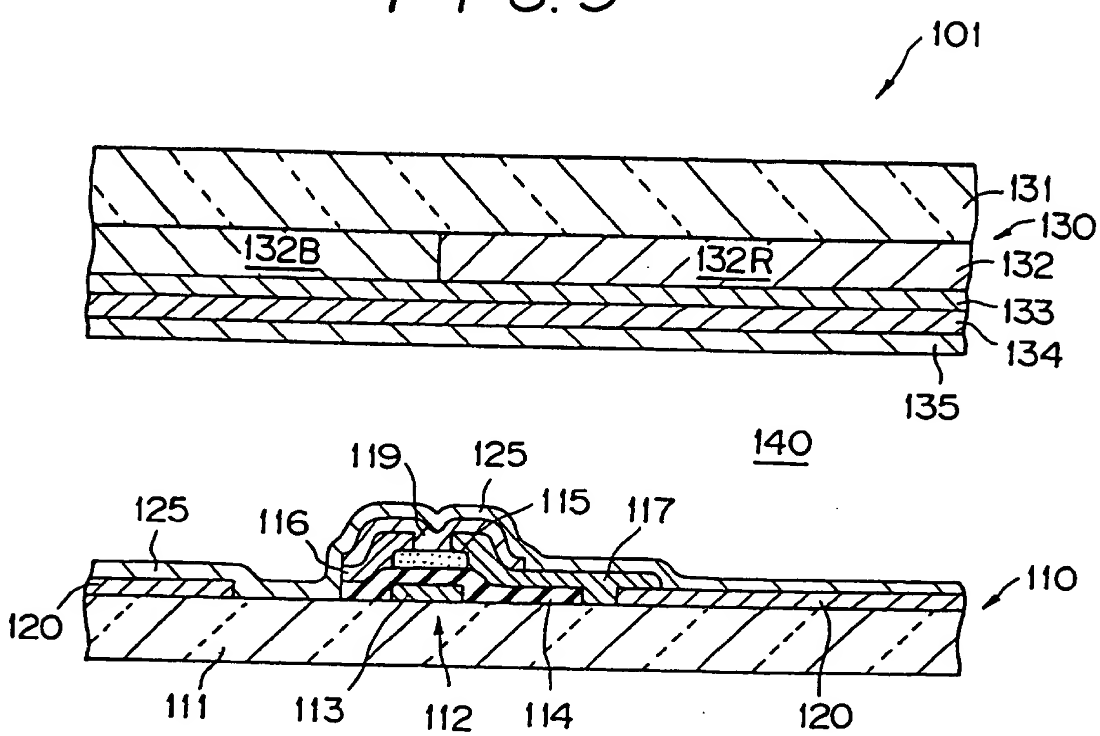
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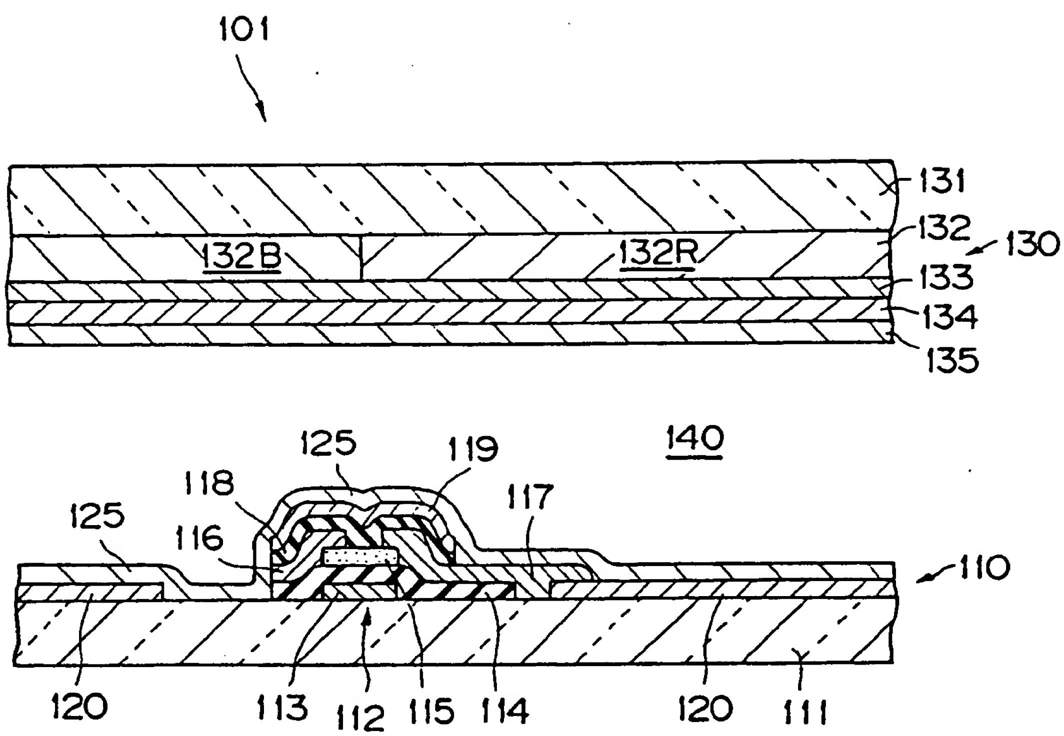
FIG. 10



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INTERNATIONAL SEARCH REPORT

International Application No PCT/JP92/00812

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl^5 G02F1/1335

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC	G02F1/1335

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
Y	JP, A, 2-34803 (Nissha Printing Co., Ltd.), February 5, 1990 (05. 02. 90), (Family: none)	1-47
Y	JP, A, 2-32616 (Nissha Printing Co., Ltd.), July 23, 1990 (23. 07. 90), (Family: none)	1-47
Y	JP, A, 1-302223 (Nissha Printing Co., Ltd.), December 6, 1989 (06. 12. 89), (Family: none)	1-47
T	JP, A, 3-209223 (Hitachi, Ltd.), September 12, 1991 (12. 09. 91), (Family: none)	1-47
T	JP, A, 3-157624 (Sanyo Electric Co., Ltd.), July 5, 1991 (05. 07. 91), (Family: none)	1-47

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
August 6, 1992 (06. 08. 92)	September 1, 1992 (01. 09. 92)
International Searching Authority	**Signature of Authorized Officer**
Japanese Patent Office	

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European Patent Office
Office européen des brevets

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22.07.1996 JP 191837/96

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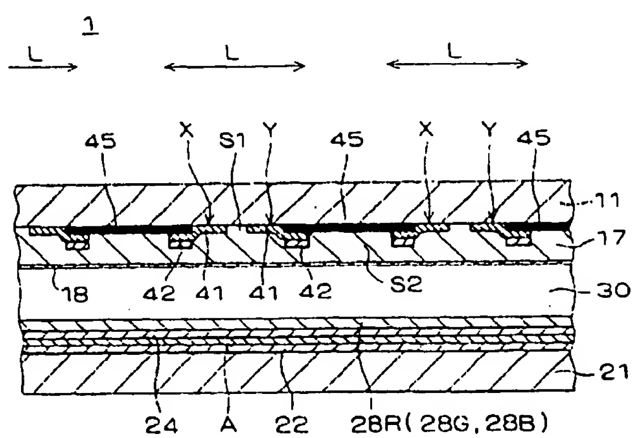
(54) A surface discharge plasma display panel and a manufacturing method therefor

(57) A surface discharge type plasma display panel (PDP) includes a pair of front and rear substrates (11, 21) with a discharge space (30) therebetween and a plurality of pair display electrodes on internal surface of either the front or rear substrate. The display electrodes extend along each display line L. The PDP further includes a light shielding film (45), extending in bands along the display line direction, formed on either internal or outer surfaces of the front substrate (11) to overlay each area S2 between the adjacent display lines L and extending between the display electrodes X and Y.

FIG. 2

FIRST EMBODIMENT



EP 0 762 463 A2

Description

The present invention relates to a surface discharge plasma display panel (hereinafter referred to as a surface discharge PDP) having a matrix display form, and a method for manufacturing such a plasma display panel.

The surface discharge PDPs are PDPs wherein paired display electrodes defining a primary discharge cell are located adjacent to each other on a single substrate. Since such PDPs can serve adequately as color displays by using phosphors they are widely used as thin picture display devices for television. And since, in addition, PDPs are the displays that are the most likely to be used as large screen display devices for high-vision pictures, there is, under these circumstances, a demand for PDPs for which the quality of their displays has been improved by increasing resolution and screen size, and by enhancing contrast.

Fig. 14 is a cross sectional view of the internal structure of a conventional PDP 90. A PDP 90 is a surface discharge PDP having a three-electrode structure and a matrix display form, and is categorized as a reflection PDP according to the form of its phosphors arrangements.

On the front of a PDP 90, on an internal surface of a glass substrate 11, paired display electrodes X and Y are positioned parallel to each other and arranged for each line of a matrix display so that they cause a surface discharge along the surface of the glass substrate 11. A dielectric layer 17, for AC driving, is formed to cover the paired display electrodes X and Y and separate them from a discharge space 30. A protective film 18 is formed on the surface of the dielectric layer 17 by evaporation. The dielectric layer 17 and the protective flm 18 are transparent.

Each of the display electrodes X and Y comprises a wide, linear transparent electrode 41, formed of an ITO thin film, and a narrow, linear bus electrode 42, formed of a thin metal film (Cr/Cu/Cr). The bus electrode 42 is an auxiliary electrode used to acquire an appropriate conductivity, and is located at the edge of the transparent electrode 41, away from the plane discharge gap. With such an electrode structure, the blocking of display light can be reduced to the minimum, while the surface discharge area can be expanded to increase the light emission efficiency.

At the rear, an address electrode A is provided on the internal surface of a glass substrate 21 so that it intersects at a right angle the paired display electrodes X and Y. A phosphors layer 28 is formed on and covers the glass substrate 21, including the upper portion of the address electrode A. A counter discharge between the address electrode A and the display electrode Y controls a condition wherein wall charges are accumulated in the dielectric layer 17. When the phosphors layer 28 is partially excited by an ultraviolet ray UV that occurs as a result of a surface discharge, it produces visible light emissions having predetermined colors. The visible light emissions that are transmitted through the glass substrate 11 constitute the display light.

A gap S1 between paired display electrodes X and Y arranged in a line is called a "discharge slit," and the width w1 of the discharge slit S1 (the width in the direction in which the paired display electrodes X and Y are arranged opposite each other) is so selected that a surface discharge occurs with a drive voltage of 100 to 200 V applied to the display electrodes. A gap S2 between a line of paired electrodes X and Y and an adjacent line is called a "reverse slit," and has a width w2 greater than the width w1 of the discharge slit S1, that is sufficient to prevent a discharge between the display electrodes X and Y that are arranged on opposite sides of the reverse slit S2. Since paired display electrodes X and Y are arranged in a line with a discharge slit S1 between them, and a line is separated from another line by reverse slits S2, each of the lines can be rendered luminous selectively. Therefore, portions of the display screen that correspond to the reverse slits S2 are non-luminous areas or non-display areas, and the portions that correspond to the display slits S1 are luminous areas or display areas.

From the front of a conventional panel structure, a phosphors layer 28 in the non-luminescent state is visible through the reverse slits S2. And the phosphors layer 28 in the non-luminescent state has a white or light gray color. Therefore, when a conventional display panel is used in an especially bright place, external light is scattered at the phosphors layer 28 and the non-luminescent areas between lines has a whitish color, which results in the deterioration of the contrast of the display.

As a method for increasing the contrast for a color display PDP, proposed are a method for providing a color filter by coating the outer surface of the substrate 11 on the front with a translucent paint that corresponds to the luminous color of a phosphors; a method for arranging on the front face of a PDP a filter that is fabricated separately; and a method for coloring a dielectric layer 17 with colors R, G and B.

It is, however, very difficult to apply coats of individually colored paints at locations corresponding to minute pixels. In case of the separate filter on the front, a gap between the PDP and the filter causes distortion in display images. And in case of the coloring of the dielectric layer 17, since the tints of coloring agents (pigments) differ, uniformity of permittivity is deteriorated by coloring, and a discharge characteristic is rendered unstable. In addition, positioning is also difficult when coloring a dielectric layer, just as the coating of colored paints .

Embodiments of the present invention are thus intended to increase display contrast while rendering unnoticeable non-luminous areas between lines.

Embodiments may further provide an optimal structure for forming a light shielding film including black pigment in non-luminous areas between display lines, and a manufacturing method therefor.

According to a first aspect of the present invention, there is provided a surface discharqe plasma display panel, wherein paired display electrodes extending along display lines are arranged for each display line on the internal surface of a substrate at the front or in the rear, and wherein a light shielding film, having a belt shape extending along the display line direction, is formed on the internal surface or the outer surface of the front substrate, so as to overlap each area sandwiched between the adjacent display electrodes.

The area corresponding to a gap (hereinafter referred to as a "reverse slit") between the display electrodes in adjacent lines on a display screen is a non-luminous area. The light shielding film is arranged to correspond with each non-luminous area. Since the plane pattern of the individual shielding films is formed in a belt shape, a striped shielding pattern is formed for the entire display screen. The shielding film blocks visible lights that may be transmitted through the reverse slits. Therefore, the occurrence of a phenomenon where non-luminous areas appear bright due to the external light and a leaking light from display lines may be prevented so that the display contrast is increased.

According to a second aspect of the present invention, there is provided a Surface discharqe plasma display panel, wherein paired display electrodes are formed for each display line on an internal surface of a front substrate extending along the display lines, and phosphor is deposited on the internal surface of a rear substrate, and wherein a light-shielding film having a darker color than the phosphors with non-luminous condition and having a belt shape extending the display line direction is formed on the internal surface or on the outer surface of the front substrate, so as to overlap each area sandwiched between the adjacent display electrodes.

When viewing the display screen from the front, the phosphors layer is hidden by the shielding film in the non-luminous areas that correspond to the reverse slits.

According to a third aspect of the present invention, there is provided a plasma display panel wherein display electrodes are covered and separated from a discharge space by a dielectric layer, and a light shielding film is located between the front substrate and the dielectric layer.

According to a fourth aspect of the present invention there is provided a plasma display panel wherein each display electrode comprises a transparent electrode and a metal electrode, which is narrower than the transparent electrode and which overlaps the edge of the transparent electrode at a location close to the non-luminous area, and wherein a light shielding film is located at the front of the display electrode in the substrade facing direction so as to overlap the metal electrodes on both sides of the non-luminous area.

Since the shielding film is also provided on the front of the metal electrode, the deterioration of display quality due to the reflection of external light from the surfaces of metal electrodes can be reduced, perhaps significantly.

According to a fifth aspect of the present invention there is provided a method of manufacturing a plasma display panel wherein the display electrodes and the light shielding film are formed on the front substrate, a coating of dielectric material is applied to form the dielectric layer, and the resultant structure is annealed. This coating and annealing process is performed twice. The thickness of the first coating is selected to be smaller than the second coating.

Since the thickness of the first dielectric coating subject to the first annealing is thin, a floating and moving of the shielding film through the softening of the dielectric material during the first annealing can be minimized so that an unnecessary extending of the shielding film toward the display electrodes to cover them can be avoided.

According to a sixth aspect of the present invention there is provided a method of manufacturing a plasma display panel wherein the display electrodes and the light shielding film are formed on the front substrate, a coating of dielectric material is applied to form the dielectric layer, and the resuultant structure is annealed. This coating and annealing process is performed twice. The first annealing temperature is set so that it is lower than the temperature at which the dielectric material is softened.

By setting the annealing temperature lower than the softening temperature, the unwanted expansion of the shielding film to cover the display electrodes can be prevented.

Further, according to the present invention, the above method for manufacturing a plasma display panel comprises the steps of:

depositing a light shielding material on a front substrate and performing patterning to form a light shielding film;

forming a transparent conductive film on the front substrate on which the light shielding film is formed, and performing patterning to provide a transparent electrode that partially overlaps the light shielding film;

painting a photosensitive material, which is insolubilized by exposure to light, to cover the light shielding film and the transparent electrode, exposing the photosensitive material as a whole from the reverse face of the front substrate and developing the photosensitive material to form a resist layer between the light shielding films; and

selectively forming a metal electrode on the exposed portion of the transparent electrode by plating it with a metal film. By using this method, self-alignment of the light shielding film and the metal electrode is performed.

In addition, according to a seventh aspect of the present invention there is provided a plasma display

panel, having a pair of substrates facing each other with a discharge space therebetween, wherein paired display electrodes, extending along display lines are formed for each display line on an internal surface of one of the pair substrates so that a discharge is performed between the paired display electrodes; and wherein a light shielding film having a stripe shape and extending along display lines is formed in an area between the display lines and sandwiched between the pair diplay electrodes on the internal surface of one of the substrates, so that the light shielding film is separated from the display electrodes.

According to a further embodiment, the light Shielding film is formed so as to partially overlap over the display electrodes.

With an arrangement wherein the display electrodes are formed first and thereafter the light shielding film is formed, the manufacture of display electrodes using a high vacuum process, such as sputtering, is more easily performed.

As a method for manufacturing the device of the above arrangement, there is provided a method for manufacturing a plasma display panel having a pair of substrates facing each other with a discharge space therebetween, comprising the steps of:

forming a plurality of pair display electrodes on one of the pair substrates to form display lines therebetween;
forming a film containing a dark pigment on the display electrodes on the substrate, and performing patterning of the film so that a stripe shaped light shielding film, extending along the display lines, is provided in an area between the display lines and sandwiched between the pair display electrodes; and
forming a dielectric paste film on the display electrodes and the light shielding film, and annealing the resultant structure at a predetermined temperature.

In all cases the contrast of the display under bright external conditions is increased by having a light shielding film extending in bands in betwen the display lines within the structure of the plasma display panel.

Fig. 1 is a perspective view illustrating the basic structure of a PDP relating to the present invention;
Fig. 2 is a cross sectional view of the essential portion of the PDP according to the first embodiment;
Fig. 3 is a plan view of a light shielding film;
Figs. 4A through 4F are diagrams illustrating a method for fabricating the front portion of the PDP;
Fig. 5 is a cross sectional view of the essential portion of a PDP according to a second embodiment of the present invention;
Fig. 6 is a cross sectional view of the essential portion of a PDP according to a third embodiment of the present invention;
Fig. 7 is a cross sectional view of the essential portion of a PDP according to a fourth embodiment of the present invention;
Fig. 8 is a cross sectional view of the essential portion of a PDP according to a fifth embodiment of the present invention;
Figs. 9A through 9E are cross sectional views for explaining a method for manufacturing the PDPs of the second, the fourth and the fifth embodiments of the present invention;
Figs. 10A through 10C are cross sectional views for explaining a method for manufacturing the PDPs of the second, the fourth and the fifth embodiments of the present invention;
Fig. 11 is a plan view of a PDP wherein a light shielding film is also formed in a periphery of a display area of the panel;
Fig. 12 is a cross sectional view of a portion taken along the line XX-YY in Fig. 11;
Fig. 13 is a cross sectional view of a modification of the PDP; and
Fig. 14 is a cross sectional view of the essential portion of the internal structure of a conventional PDP.

Fig. 1 is a perspective view illustrating the basic structure of a PDP 1 according to the present invention. The same reference numerals as used in Fig. 14 are also used in Fig. 1 to denote corresponding or identical components, regardless of differences in shapes and materials. The same can be applied for the following drawings.

The PDP 1, as well as the conventional PDP 90, is a surface discharge PDP having a three-electrode structure with a matrix display form, that is called a reflection type. The external appearance is derived from paired glass substrates 11 and 21, which face each other with an intervening discharge space 30 therebetween. The glass substrates 11 and 21 are bonded by a seal frame layer (not shown) of a glass having a low-melting point that is formed along the edges of the facing substrate.

A pair of linear display electrodes X and Y in parallel are arranged for each line L of a matrix display on the internal surface of the front glass substrate 11, for the generation of a surface discharge along the substrate surface. The line pitch is, for example, 660 μm.

Each of the display electrodes X and Y comprises a wide, linear transparent electrode 41 formed of ITO thin film and a narrow, linear bus electrode 42 formed of metal thin film having a multi-layer structure. As specific example sizes, the transparent electrode 41 is 0.1 μm thick and 180 μm wide, while the bus electrode 42 is 1 μm thick and 60 μm wide.

The bus electrode 42 is an auxiliary electrode for acquiring appropriate conductivity, and is located at the edge of the transparent electrode 41 away from a surface discharge gap.

For the PDP 1, a dielectric layer for (example PbO low-melting-point glass layer) 17 for AC driving is

formed to cover the display electrodes X and Y and separate them from the discharge space 30. A protective film 18 made of MgO (magnesium oxide) for example is deposited on the surface of the dielectric layer 17 by evaporation. The thickness of the dielectric layer 17 is about 30 µm and the thickness of the protective film 18 is approximately 5000 Å for example.

The internal surface of the rear glass substrate 21 is coated with an underlayer 22 of approximately 10 µm, which is ZnO low-melting-point glass for example. Address electrodes A are arranged on the underlayer 22 at constant pitches (for example 220 µm), so that they intersect the paired display electrodes X and Y at a right angle. The address electrode A is produced by annealing silver paste for example, and its thickness is about 10 µm. The underlayer 22 prevents electromigration of the address electrodes A.

The condition of wall electric charge accumulation on the dielectric layer 17 is controlled by a discharge between the address electrodes A and the display electrodes Y. The address electrodes are also covered with a dielectric layer 24 that is formed of low-melting-point glass with the same composition for example as that of the underlayer 22. The dielectric layer 24 at the upper portions of the address electrodes A is about 10 µm thick for example.

On the dielectric layer 24, a plurality of barrier ribs 29, which are about 150 µm high and linear in a plan view, are individually arranged between the address electrodes A.

Then, phosphors layers 28R, 28B and 28C (hereinafter referred to as the "phosphors layers 28," when distinguishing between colors is not especially required), for the three primary colors R (red), G (green) and B (blue) of a full-color display, are formed so as to cover the surface of the dielectric layer 24, including the upper portions of the address electrodes A, and the sides of the barrier ribs 29. These phosphors layers 28 emit light when they are excited by the ultraviolet rays produced by the surface discharge.

The discharge space 30 is defined by the barrier ribs 29 for the units of light emitting areas along the lines (along the arrangement of pixels running parallel with the display electrodes X and Y), and the size of a gap between the discharge space 30 is also defined. In the PDP 1, there are no barrier ribs for defining the discharge space 30 along the columns for a matrix display (along the arrangement direction of the paired display electrodes X and Y or the address lines direction). However, since the size of a gap (the width of a reverse slit) for display lines L, along which the paired display electrodes X and Y are arranged, is set to from 100 to 400 µm, sufficiently large compared with the size of a surface discharge gap (the width of a discharge slit) of 50 µm for each display line L, the interference of a discharge does not occur between the lines L.

A display pixel of the PDP 1 comprises three unit light emitting areas (sub-pixels) adjacent each other in each line L. The luminous colors for all the lines L in the same column are the same, and the phosphors layers 28R, 28B and 28C are so provided by screen printing that they are continuously arranged in each column along the address electrode. For this, screen printing provides excellent productivity. Compared with an arrangement wherein the phosphors is divided for each line L, the arrangement of the continuous phosphors layers 28 along a column can easily provide the uniform thickness of the phosphors layers 28 for the sub-pixels.

Fig. 2 is a cross sectional view of the essential portion of the PDP 1, and Fig. 3 is a plan view of a light shielding film 45. As is shown in Fig. 2, a light shielding film 45 for blocking (shielding) a visible light is formed for each reverse slit S2, so that the film 45 directly contacts the internal surface of the glass substrate 11. As is shown in Fig. 3, the shielding films 45 are formed in patterns of belts or strips that extend along the display lines, and are located to overlap the areas sandwiched between the display electrodes X and Y of the adjacent lines L. The light shielding films 45 separated from each other constitute a striped shielding pattern for an entire display screen, so that the phosphors layers 28 are hidden between the display lines L and the contrast for a display is increased. Since the striped pattern along the display line L does not shift along the display lines L, unlike a matrix pattern surrounding the sub-pixels or pixels, it is easy to align and position the glass substrates 11 and 21 during the manufacturing of the PDP 1.

It is preferable that the top portions of the barrier ribs 29 have the same dark color as that of the light shielding films. A dark lattice pattern is formed by intersecting the barrier ribs and the light shielding films, and the outline of each sub-pixel becomes clear. More specifically, a black color agent, such as chromium (Cr), is mixed with the material for the barrier ribs to provide uniformly dark barrier ribs.

Figs. 4A through 4F are diagrams illustrating a method for manufacturing the front side portion of the PDP 1. The PDP 1 is produced by providing predetermined components independently for the glass substrate 11 and the glass substrate 21, and by thereafter bonding together the glass substrates 11 and 21 around their circumferences while they are positioned facing each other.

For fabrication of the front portion, first, a dark colored insulating material is deposited on the surface of the glass substrate 11 by sputtering to form an insulation film (not shown) having a surface reflectivity lower than that of the metal electrode 42. Chromium oxide (CrO) or silicon oxide can be used as the insulation material. It is desirable that the thickness of the insulation film be 1 µm or less in order to reduce the step difference to the transparent electrodes 41. Then, patterning is performed to the insulation film by photolithography using a first light exposing mask, and a plurality of the light shielding film stripes 45 described above are produced at one time (Fig. 4A).

Sequentially, an ITO film is deposited on the glass substrate 11, whereon the light shielding films 45 are formed, and patterning of the ITO film is performed by photolithography using a second light exposing mask. Transparent electrodes 41 are thus formed so that they partially overlap the light shielding films 45 (Fig. 4B).

A negative photosensitive material 61, which is irreversibly solidified by exposure to ultraviolet rays, is coated on the resultant structure so that it covers the light shielding films 45 and the transparent electrodes 41. The photosensitive material is fully exposed to the light from the reverse side of the glass substrate 11 (Fig. 4C). Then, the photosensitive material 61 is developed and forms a resist layer 62 which covers only an area between the light shielding films 45 (Fig. 4D).

Following this, the metal electrodes 42, having a multiple layer structure of, for example, nickel/copper/nickel, are formed on the exposed portions of the transparent electrodes 41 by selective plating (Fig. 4E).

The resist layer 62 is removed, and the dielectric layer 17 and the protective film 18 are deposited in order. The front portion of the PDP 1 is thus produced (Fig. 4F).

In the above described process, the number of required light exposing masks is two (Figs. 4A and 4B), the same as is required by the fabrication process for the conventional PDP 90, and the number of alignment procedures for the exposing masks is one, also the same as in the conventional process. In other words, according to the fabrication method in Fig. 4, the light shielding films 45 can be formed without deterioration of a yield due to a shift in alignment.

Fig. 5 is a cross sectional view of the essential portion of a PDP 2 according to a second embodiment of the present invention, i.e., showing the front portion of a discharge space. In the PDP 2, light shielding films 46 having the same width as the reverse slit S2 are provided on the internal surface of a front glass substrate 11. As well as the light shielding films 45 in Fig. 3, the light shielding films 46 are extended in a belt shape along the display line in a plan view, and constitute a striped light shielding pattern.

For fabrication of the PDP 2, paired display electrodes X and Y are formed on the glass substrate 11. And a black pigment, such as iron oxide or cobalt oxide, that has a heat resistance of 600°C or higher is printed on the reverse slit area S2 to form the light shielding films 46. Low-melting-point glass is coated and annealed at 500 to 600°C to produce the dielectric layer 17.

It is preferable that the thickness of the light shielding films 46 be less than the thickness of the individual display electrodes so as to acquire the flat surface of the dielectric layer 17. Further, it is desirable that the dielectric layer 17 be formed in two layers, and that annealing be performed for each layer. More specifically, a comparatively thin coat of low-melting-point glass paste is applied to the substrate and the glass paste is annealed to form a lower dielectric layer 17a. Then, another coat of the low-melting-point glass paste is applied to acquire a dielectric layer 17 having the required thickness, and the glass paste is annealed to produce an upper dielectric layer 17b. Since the lower dielectric layer 17a, which contacts the light shielding layers 46, is formed thin, the migration of a black pigment caused through the softening of the low-melting-point glass during the annealing, can be reduced, and the reduction in luminance due to the unwanted expansion of the light shielding films 46 can be prevented. When the thickness of the lower dielectric layer 17a is so set that it is one tenth of or less than the width of the light shielding films 46, the migration of the pigment does not substantially appear.

It should be noted that the unwanted expansion of the light shielding films 46 can also be prevented by setting the temperature for annealing the lower dielectric layer 17a to a temperature that is lower than that for softening the low-melting-point glass. In this case, the lower dielectric layer 17a and the upper dielectric layer 17b can be formed with the same thickness, or the upper dielectric layer 17b can be formed thinner than the lower dielectric layer 17a.

Fig. 6 is a cross sectional view of the essential portion of a PDP 3 according to a third embodiment of the present invention, and shows the structure of the front side portion of the discharge space. In the PDP 3, a light shielding film 47 is provided for each reverse slit S2 in an intermediate portion in the direction of the thickness of a dielectric layer 17. The light shielding film 47, as well as the light shielding films 45 in Fig. 3, are extended in a belt shape along the display line in a plan view, and constitute a striped light shielding pattern.

A width w47 of the light shielding film 47 is greater than a width w2 of the reverse slit S2, and is smaller than the interval w22 between the edges, which are closer to the discharge slit S1, of the metal electrodes 42 sandwiching the reverse slit S2. In other words, the plane size of the light shield film 47 is so selected that it partially overlaps the metal electrodes 42. With this structure, the light shielding film 47 can be easily positioned so that it fully overlaps the reverse slit S2 and does not overlap the light transmitting portion 41 in the display line. It is also important that the light shielding film 47 is apart from the electrodes 41,42.

Fig. 7 is a cross sectional view of the essential portions of a PDP 4 according to a fourth embodiment of the present invention. The light shielding films 45 shown in Fig. 2 are formed between the X and Y electrodes 41 and 42 and the front glass substrate 10. In the PDP 4 shown in Fig. 7, light shielding films 49 are formed inside the reverse slit S2 areas between the X and Y electrodes 41 and 42 so that they partially overlap the X and Y electrodes 41 and 42. This structure is similar to that in Fig. 2 because the light shielding films 49 are so formed that they completely hide the reverse slit S2 areas between the display lines L. However, the manufacturing process for this structure differs from that in Fig. 2 in that the light shielding films 49 containing a black pigment are formed

after the X and Y electrodes 41 and 42 are provided. This manufacturing process will be described later in detail.

In the structure of the PDP 4 shown in Fig. 7, it is important for the light shielding films 49 to overlap the electrodes X and Y up to around the middle portions of the bus electrodes 42, which constitute a three-layer structure of Cr/Cu/Cr. In other words, while the bus electrodes 42 provide a higher conductivity for a highly resistant material for the transparent electrodes 41, the electrodes 42 themselves possess light shielding property. When the light shielding films 49 are so formed that they overlap the bus electrodes 42, the portions, except for the display line areas L, are completely shielded.

Fig. 8 is a cross sectional view of the essential portion of a PDP 5 according to a fifth embodiment of the present invention. In the PDP 5, light shielding films 48 are formed between X and Y electrodes 41 and 42 at a certain interval and without making contact with them. When the distance of the non-display areas between the X and Y electrodes 41 and 42 is 500 μm (using as an example a 42-inch PDP), the light shielding film 48 is formed at an interval of about 20 μm from the electrodes 41 and 42. This structure is preferable from the view of the manufacturing process for it, even though the gap between the display line areas L is not completely closed. More specifically, as well as with the PDP 4 in Fig. 7, the light shielding films 48 can be formed after the X and Y electrodes 41 and 42 are provided. Moreover, the annealing of the light shielding films 48 can be performed in conjunction with the annealing process for the dielectric layer 17, made of a low-melting-point glass, that is formed on them. Since the light shielding films 48 do not contact the electrodes 41 and 42 in the annealing process at a high temperature, a stable process can be accomplished. This will be described later in detail.

In the structure of the PDP 5 in Fig. 8, since the width of the light shielding films 48 is considerably smaller than the non-display area W22, there is sufficient space so that when the alignment (positioning) of the light shielding films 48 is performed, the films 48 can be easily formed not to overlap the display line areas L.

Figs. 9A through 9E and 10A through 10C are cross sectional views for explaining a method for respectively fabricating the PDPs of the second, fourth, and fifth embodiments, shown in Figs. 5, 7 and 8.

As is shown in Fig. 9A, after a silicon oxide film (not shown), for example, is formed as a passivation film on a glass substrate 11, a transparent electrode layer 41 is formed across the entire surface by sputtering. The transparent electrode layer 41 is formed with a thickness of approximately 0.1 μm by using ITO. Then, in the common lithography procedure, the transparent electrode layer 41 is formed in a striped pattern to provide X and Y electrodes 41 having a width of about 180 μm.

Sequentially, as is shown in Fig. 9B, a metal layer 42 having a three-layer structure of Cr/Cu/Cr is formed as a bus electrode layer of about 1 μm on the entire surface by sputtering. The common lithography procedure is performed to pattern the metal layer 42 to approximately 60 μm. As is previously described, the bus electrode 42 is so formed that it is positioned at the end of the side opposite to the side of the electrode 41 faces each other closely.

For the formation of the X and Y electrodes 41 and 42, sputtering is performed on the glass substrate 11 after it is placed in a high vacuum chamber. Since a light shielding film containing a black pigment, etc., is not formed on the glass substrate 11, the sputtering under a high vacuum can be stably performed.

Then, as is shown in Fig. 9C, a photoresist layer 71 containing a black pigment is formed by screen printing. The black pigment is oxide of manganese (Mn), iron (Fe), or Copper (Cu), for example. Such a pigment is mixed in a photoresist including photosensitive material. For example, a pigment dispersion photoresist (product name: CFPR BK) of Tokyo Ohka Kogyo Co., Ltd. is used.

Following this, as is shown in Fig. 9D, the resultant structure is exposed to light through a predetermined mask pattern, and developed. Then, baking (drying) is performed on the structure for two to five minutes in a dry atmosphere at 120°C to 200°C, for example, to form the light shielding films 49. In the example shown in Fig. 9D, as for the PDP 4 shown in Fig. 7, the light shielding films 49 is patterned to overlap the X and Y electrodes 41 and 42.

When a different mask pattern is used, the light shielding films 48 can be formed separately from the X and Y electrodes 41 and 42, as is shown in Fig. 9E. This structure corresponds to that of the PDP 5 shown in Fig. 8. Similarly, the light shielding films 46 can be formed as are shown for the structure in Fig. 5.

As is described above, a photosensitive resist of a polymer organic material is used for the light shielding films 49 and 48. If, prior to the formation of the electrodes 41 the light shielding films are formed and annealed for stability, the contact of the electrodes 41 may be deteriorated due to an uneven surface of the film. From this point of view, the process in Fig. 9 is an effective one.

Figs. 10A through 10C are cross sectional views of a method for forming a dielectric layer 17 and a MgO protection layer 18 on light shielding films. An explanation will be given for this example by employing the light shielding films 48, shown in Figs. 8 and 9E, that are formed separately from the electrodes 41 and 42.

In the fabrication process for the dielectric layer 17 shown in Fig. 10, annealing of the light shielding films 48 is also performed together with the procedure for annealing the dielectric layer 17. For the formation of the dielectric layer 17, a low-melting-point glass paste containing lead oxide (PbO) as the main element is printed on the surface of the substrate, and is then annealed. This process involves at least two procedures: the printing and the annealing of the lower dielectric layer 17a

and the upper dielectric layer 17b. Specifically, as a material for the lower dielectric layer 17a, a composition is selected for which the viscosity is not decreased in the annealing atmosphere and which does not easily react with the ITO of the transparent electrodes 41 and the copper (Cu) of the bus electrodes 42. Such a composition material is, for example, a glass paste that comprises $PbO/SiO_2/B_2O_3/ZnO$, and that contains a comparatively large amount of SiO_2.

As a material for the upper dielectric layer 17b, a composition is selected for which the viscosity is adequately decreased in the annealing atmosphere and the surface is flattened. As such a composition material, a glass paste which comprises $PbO/SiO_2/B_2O_3/ZnO$ and contains a comparatively small amount of SiO_2 is selected.

As is shown in Fig. 10A, the surface of the glass substrate 11 is printed by a glass paste, which comprises $PbO/SiO_2/B_2O_3/ZnO$ and contains a comparatively large amount of SiO_2. The substrate 11 is then annealed for about 60 minutes in a dry atmosphere at 580°C to 590°C. The viscosity of the glass paste is not much decreased at the annealing temperature, and the paste does not easily react with the ITO of the transparent electrodes 41 and the copper (Cu) of the bus electrodes 42. Further, the glass paste is annealed at the same time as the light shielding films 48. Therefore, a savings in the time and labor required for the annealing process can be realized, as compared with the example wherein the light shielding films 48 are formed prior to the electrodes 41 and 42.

Next, as is shown in Fig. 10B, the upper dielectric layer 17b is formed. In the same manner as for the lower dielectric layer 17a, the substrate is printed by using a glass paste and is annealed for about 60 minutes in a dry atmosphere at 580°C to 590°C. The preferable glass paste is one that comprises $PbO/SiO_2/B_2O_3/ZnO$ and contains a comparatively small amount of SiO_2, as is described above. As a result, the dielectric layer 17 having a flat surface is formed.

Finally, a thick layer of low-melting-point glass film for sealing is formed around the edges of the glass substrate 11 (not shown), and then, as is shown in Fig. 10C, the MgO film 18 is formed as a protective film by evaporation.

Although the light shielding films 48 are formed separately from the electrodes 41 and 42 in the process shown in Fig. 10, as previously described, the light shielding films may contact the electrodes 41 as in the PDPs 2 and 4 shown in Figs. 5 and 7. Though the reason is still not well understood, when a substrate on which light shielding films are in contact with electrodes 41 and 42 is placed in an annealing atmosphere at a temperature close to 600°C, the light shielding films may be turned brown, and to prevent this, it may be effective for the light shielding films to be separated from the electrodes 41 and 42 in the same manner as for the light shielding films 48. The separation interval in this case is called a color change prevention gap for convenience sake.

Fig. 11 is a plan view of a PDP wherein light shielding films 48 are formed in the periphery outside a display area of the panel. Fig. 12 is a cross sectional view of the portion taken along the line XX-YY in Fig. 11. As is described above, the contrast of a display is increased by forming light shielding films 48 between the X and Y electrodes in the areas between the display lines L1, L2 and L3. In Fig. 11, the light shielding films 48 are also formed in a peripheral area.

In the PDP, to prevent an occurrence of accidental discharge, dummy X and Y electrodes DX and DY, are formed at the peripheral portions of paired X and Y electrodes X1, Y1, X2, Y2, X3 and Y3, which commonly serve as display electrodes. Wall charges not required for display are prevented from being accumulated by frequently performing discharges between the dummy electrodes DX and DY also. The discharges performed in the peripheral area and the exposure of the phosphors layer cause contrast in a display area to be deteriorated. Therefore, as is shown in Fig. 11, the light shielding films 48 are formed on the dummy electrodes DX and DY (indicated as Dummy in Fig. 11), and on a peripheral area PE where leads 42R of bus electrodes 42 are formed. The EX described by the chain lines is a display screen frame on the surface of the panel, and a sealing member 50 is formed at a position on the frame EX to seal the glass substrates. In the cross sectional view in Fig. 12, the front glass substrate 11 and the sealing member 50 formed on the MgO film 18 are shown, while a rear glass substrate is omitted.

The leads 42R of the bus electrodes 42 are connected to an external controller via a flexible cable (not shown). Therefore, the two glass substrates are sealed together by the sealing member 50 at the portion of the leads 42R of the bus electrodes 42.

[Material for light shielding film]

An explanation has been given for the process for forming the dielectric layer 17 on the light shielding films 48 and annealing them at about 600°C, as is shown in Figs. 10A through 10C. If the display electrodes and the light shielding films are in contact with each other, the black color of the light shielding films 48 may be changed. Although the reason is not well understood, it seems that the display electrodes and the light shielding films that are in contact with each other tend to be ionized during the annealing process, and the low-melting-point glass paste absorbs oxygen from the oxides of Mn, Fe and Cu, which are contained in the black pigment, and the oxides are reduced. Thus, an effective means to prevent the color change is for an oxide agent actively discharging oxygen to be mixed in the photosensitive resist 71 containing the black pigment, which is formed into the light shielding films.

The specific oxide agents that were used in this

manner are $NaNO_3$, BaO_2, etc. And as a result, it was confirmed that no color change occurred, even when the annealing process was completed.

The light shielding films can increase the contrast for a display in the PDP by not leaking light to the exterior from inside the PDP. However, because of the black color, external light is regularly reflected from the phase boundary between the light shielding films 48 and the glass substrate 11, and as a mirror image due to this regular reflection appears, it is sometimes difficult to look at the display screen. Even in the conventional structure in which light shielding films are not formed, the regular reflection between the paired display electrodes occurs on the surface of the address electrodes at the back substrate. To prevent the regular reflection from occurring at the phase boundary between the light shielding films 48 and the glass substrate 11, a low-melting-point glass powder is mixed in the material for the light shielding films.

The low-melting-point glass powder is the same material as the dielectric layer 17, for example, and is contained about 50% in the organic photosensitive resist 71. The organic photosensitive resist 71, therefore, contains a black pigment and low-melting-point glass powder. Although, as in conventional manner, the regular reflection of external light occurs on the outer surface of the front glass substrate 11, the refractive index of the light shielding film 48 is close to that of the glass substrate 11 at their phase boundary, and accordingly, the reflectivity is reduced to about half. Further, light is absorbed by the black pigment contained in the light shielding films 48, and accordingly, reflected light is also reduced. Therefore, the regular reflection at the display screen is reduced as a whole, and the unclear display due to mirror imaging is improved.

When low-melting-point glass was not mixed in the light shielding films 48, the regular refractive index was approximately 8% (4% at the glass outer surface and 4% at the phase boundary). When low-melting-point glass powder was mixed into the light shielding films 48, regular refractive index was reduced to about 6% (4% at the glass outer surface and 2% at the phase boundary).

As is described above, the light shielding films are formed to increase the contrast for a display screen. For this formation, an oxide agent is mixed in the organic photosensitive resist 71 to prevent a color change from occurring during the annealing process, and the low-melting-point glass is mixed in to prevent regular reflection.

As a method for preventing the change in the color of the light shielding films, proposed is a method wherein the display electrodes are coated with a thin insulation film, such as SiO_2 film, to keep the light shielding films from contacting the display electrodes.

Fig. 13 is a cross sectional view of a modification of the PDP, showing a front glass substrate 11 and a rear glass substrate 12. In this modification, as light shielding films 48, light shielding films 48A are formed on the outer surface of the front substrate 11 in the areas between the display lines L; light shielding films 48B are formed inside a dielectric layer 17; and light shielding films 48C are formed above a phosphors film 24 on the rear glass substrate 21.

Regardless of the locations at which the light shielding films 48 are formed, light from the phosphors film 24 can be prevented from leaking out to the front.

Although the reflection PDPs 1 through 5 are employed for the above explanation, the present invention can also be applied for a transmission PDP in which a phosphors layer 28 is formed on a front glass substrate 11. And light shielding films may be formed on the outer surface of the glass substrate 11. It should be noted that in this case, an alignment process between the glass substrates is required.

According to embodiments of the present invention, non-luminous areas between display lines can be shielded so they are not noticeable, and the contrast for a display can be increased.

According to these embodiments, reflection of external light at the surface of a phosphors layer can be prevented to varying extents, and a display having high contrast can be provided.

According to these embodiments, reflection of external light can be prevented not only at the area between the display line but also at the surface of a metal electrode, and a display having high contrast can be achieved.

According to these embodiments, expansion of light shielding films may be prevented in the process for forming a dielectric layer, and reduction of luminance can be prevented.

According to the above embodiments, since light shielding films can be formed without increasing the number of mask alignment processes for patterning, a high yield can be maintained and the contrast for a display can be increased.

According to the above embodiments, after display electrodes are formed, light shielding films and a dielectric layer can be formed and annealed together, and a comparatively stable process can be performed.

Claims

1. A surface discharge plasma display panel, having paired front and rear substrates and a discharge space therebetween, and a plurality of paired display electrodes extending along each of a plurality of display lines and formed on the internal surface of either the front or the rear substrate, the surface discharge plasma display panel further comprising;

   a light shielding film extending in bands along the display line direction, the bands being formed on the internal or outer surface of the front substrate so as to overlay the gaps between adjacent display

lines and which are located between adjacent display electrodes.

2. A surface discharge plasma display panel, having paired front and rear substrates and a discharge space therebetween, a plurality of paired display electrodes extending along each of a plurality of display lines and being formed on the internal surface of the front substrate, and having phosphors provided on the internal surface of the rear substrate, the surface discharge plasma display panel further comprising;

   a light shielding film, extending in bands along the display line direction, having a darker color than the phosphors, the bands being formed on the internal or outer surface of the front substrate so as to overlay the gaps between adjacent display lines and which bands are located between adjacent display electrodes.

3. A surface discharge plasma display panel of claim 1 or claim 2, further comprising,

   a dielectric layer formed on the internal surface of the front substrate to overlay the display electrodes,
   wherein the one or more light shielding bands are formed between the front substrate and the dielectric layer.

4. A surface discharge plasma display panel of claim 1 or claim 2, further comprising,

   a dielectric layer formed on the internal surface of the front substrate to overlay the display electrodes,
   wherein the one or more light shielding bands are provided at the intermediate portion in the thickness direction of the dielectric layer and separated from the display electrode.

5. A surface discharge plasma display panel of claim 3 or claim 4, wherein

   the display electrode comprises a transparent and conductive layer,
   the light shielding are made of a dark material including one or more of Mn, Fe and Cu, are located between the display electrodes and are separated from the display electrodes with a color change preventing gap in between.

6. A surface discharge plasma display panel of claim 1 or claim 2, wherein

   the display electrode comprises a transparent electrode and a metal electrode having a narrower width than the transparent electrode and overlapping the edge of the transparent electrode close to the non-luminous area, and
   the one or more light shielding bands are provided at the front side of the display electrode to overlap the metal electrode at both sides.

7. A method for manufacturing a surface discharge plasma display panel having paired front and rear substrates and a discharge space therebetween, a plurality of paired display electrodes extendinq alona each of a plurality of display lines which are formed on the internal surface of the front substrate, and phosphors provided on the internal surface of the rear substrate, the method comprising steps of:

   forming the display electrodes on the internal surface of the front substrate;
   forming a light shielding film in bands extending along the display line direction and having a darker color than the phosphors, on the internal surface of the front substrate so as to overlap each area between the adjacent display lines and which bands are located between the display electrodes;
   coating a dielectric layer having a first thickness on the internal surface of the front substrate to cover the display electrodes and the light shielding film and annealing the dielectric layer; and
   coating a further dielectric layer having a second thickness larger than the first thickness on said dielectric layer and annealing the further dielectric layer.

8. A method for manufacturing a surface discharge plasma display panel, having paired front and rear substrates with a discharge space therebetween, a plurality of paired display electrodes extending along each one of a plurality of display lines which are formed on the internal surface of the front substrate, and phosphors provided on the internal surface of the rear substrate, the method comprising the steps of:

   forming the display electrodes on the internal surface of the front substrate;
   forming a light shielding film in bands extending along the display line direction and having a darker color than the phosphors, on the internal surface of the front substrate so as to overlap each area between the adjacent display lines and which are located between the display electrodes;
   coating a dielectric layer on the internal surface of the front substrate to cover the display electrodes and the light shielding film and annealing the dielectric layer at a temperature lower than the softening temperature of the dielectric lay-

er; and
coating a second dielectric layer on said dielectric layer and annealing the second dielectric layer.

9. A method for manufacturing a surface discharge plasma display panel, having paired front and rear substrates with a discharge space therebetween, a plurality of paired display electrodes extending along each one of a plurality of display lines and formed on the internal surface of the front substrate, and phosphors provided on the internal surface of the rear substrate, the method comprising steps of:

forming a light shielding film in bands extending along the display line direction and having a darker color than the phosphors, on the internal surface of the front substrate so as to overlap each area between the adjacent display lines and which are located between the display electrodes;
forming a transparent conductive layer on the internal surface of the front substrate and patterning the transparent conductive layer to form a transparent electrode partially overlapping the light shielding film;
coating a photosensitive material, which is insolubilized by exposure, to cover the light shielding film and the transparent electrode, exposing the photosensitive material to light from the outer side of the front substrate, and developing the photosensitive material to form a resist layer between the stripes of the light shielding film; and
selectively forming a metal electrode on the exposed portion of the transparent electrode by plating.

10. A plasma display panel, having a pair of substrates with a discharge space therebetween and a plurality of paired display electrodes extending along each of a plurality of display lines and which are formed on the internal surface of one of the substrates, a discharge being caused between the paired display electrodes, the plasma display panel comprising:

a light shielding film arranged in bands extending along the display line direction, formed on the internal surface of one of the substrates so as to overlay each area between the adjacent display lines and which are located between the display electrodes,
wherein said display electrodes are provided to partially overlap the light shielding film.

11. A plasma display panel, having a pair of substrates with a discharge space therebetween and a plurality of paired display electrodes extending along each of a plurality of display lines and which are formed on the internal surface of one of the substrates, a discharge being caused between the paired display electrodes, the plasma display panel comprising:

a light shielding film, arranged in bands extending along the display line direction, formed on the internal surface of one of the substrates so as to overlay each area the adjacent display lines and which bands are located between the display electrodes,
wherein the bands of the light shielding film make contact with the edges of said display electrodes.

12. A plasma display panel, having a pair of substrates with a discharge space therebetween and a plurality of paired display electrodes extending along each of a plurality of display lines and which are formed on the internal surface of one of the substrates, a discharge being caused between the paired display electrodes, the plasma display panel comprising:

a light shielding film formed in bands, extending along the display line direction, on the internal surface of one of the substrates so as to overlay each area between the adjacent display lines and which are located between the display electrodes,
wherein the bands of the light shielding film do not make contact with said display electrodes.

13. A plasma display panel, having a pair of substrates with a discharge space therebetween and a plurality of paired display electrodes extending along each of a plurality of display lines and which are formed on the internal surface of one of the substrates, a discharge being caused between the paired display electrodes, the plasma display panel comprising:

a light shielding film, extending in bands along the display line direction, formed on the internal surface of one of the substrates so as to overlay each area between the adjacent display lines and which are located between the display electrodes,
wherein the bands of the light shielding film partially overlap said display electrodes.

14. A plasma display panel, having a pair of substrates with a discharge space therebetween and a plurality of paired display electrodes extending along each of a plurality of display lines and which are formed on the internal surface of one of the substrates, a discharge being caused between the paired display electrodes, the plasma display panel comprising:

a light shielding film, extending in bands along

the display line direction, formed on the internal surface of one of the substrates so as to overlap each area between the adjacent display lines and which bands are located between the display electrodes,
said light shielding film being further provided at a peripheral area of an effective display area.

15. A plasma display panel of claims 1, 2, 3, 4, 5, 6, 10, 11, 12, 13 or 14, wherein
said front or one substrate comprises glass, and the light shielding film includes glass material.

16. A method for manufacturing a plasma display panel, having a pair of substrates with a discharge space therebetween and a plurality of paired display electrodes extending along each of a plurality of display lines and which are formed on the internal surface of one of the substrates, a discharge being caused between the paired display electrodes, the method comprising the steps of:

forming the paired display electrodes on one of the substrates;
forming a film including a dark pigment on the display electrodes and on the one substrate, patterning the film to form a light shielding film extending in bands along the display line direction, the bands overlaying each gap between adjacent display lines and being located between the display electrodes; and
forming a dielectric paste layer over the display electrodes and the light shielding film and annealing the dielectric material layer at a predetermined temperature.

17. The method for manufacturing a plasma display panel according to claim 16, wherein
said film including the dark pigment is made of a photosensitive material, and the said film and the dielectric paste layer are annealed at the same time.

18. A method for manufacturing a plasma display panel of claim 16 or 17, wherein
the said dark pigment including film further includes an oxidizing agent.

19. A method for manufacturing a plasma display panel of claim 16, 17 or 18 wherein

said step of forming and annealing the dielectric paste includes:
a step of forming and annealing a first dielectric paste having a first viscosity at an anneal temperature and
a step of forming and annealing a second dielectric paste having a second viscosity lower than the first viscosity at the anneal temperature.

20. A surface discharge plasma display panel, having a pair of front and rear substrates with a discharge space therebetween, wherein

said front substrate is transparent and includes a plurality of paired parallel display electrodes corresponding to a plurality of display lines on the internal surface thereof, and
said rear substrate includes, on the internal surface thereof, a plurality of address electrodes in a direction intersecting the display electrodes, a plurality of barrier ribs provided between the adjacent address electrodes, and a phosphor layer having a strip pattern formed between the adjacent barrier ribs to cover the address electrodes,
said surface discharge plasma display panel comprising:
a light shielding film extending in bands along the display line direction and having a darker color than the phosphors, the bands being formed on the internal surface of the front substrate so as to overlap each area between the adjacent display lines and which bands are located between the display electrodes;
wherein the barrier ribs include a top portion which is darker than the phosphors, and wherein a lattice shape dark pattern is provided, by the light shielding film and the barrier ribs crossing each other, to define a boundary of the plurality of display pixels which constitute each said display line.

FIG. 1

BASIC STRUCTURE OF PDP

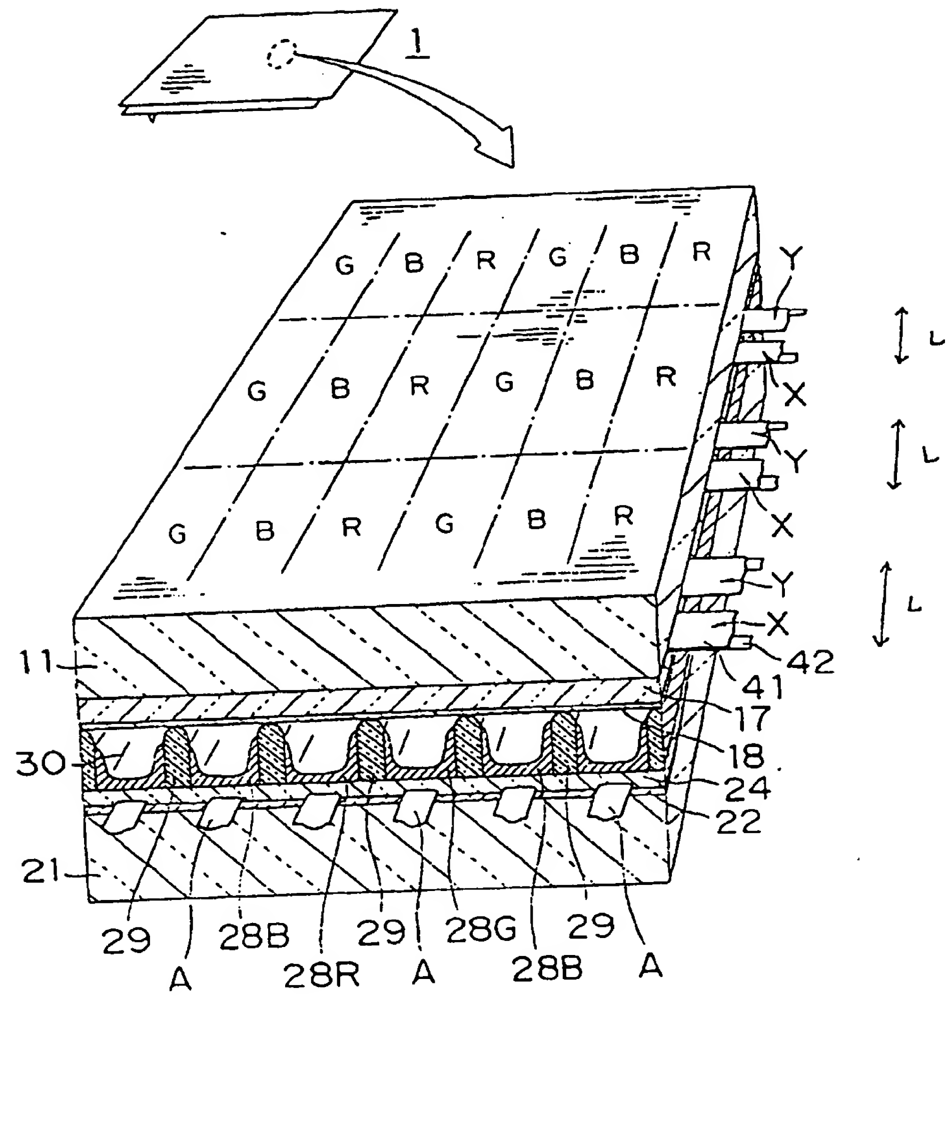


FIG. 2

FIRST EMBODIMENT

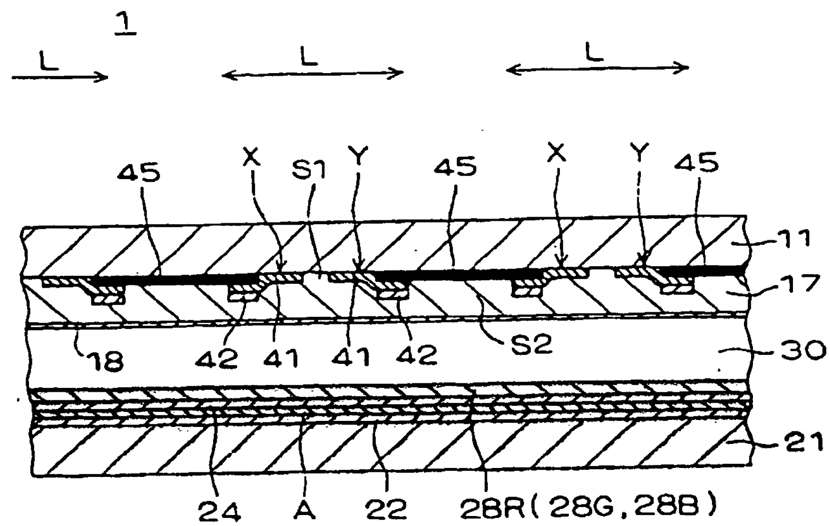


FIG. 3

PLAN VIEW OF LIGHT SHIELDING FILM

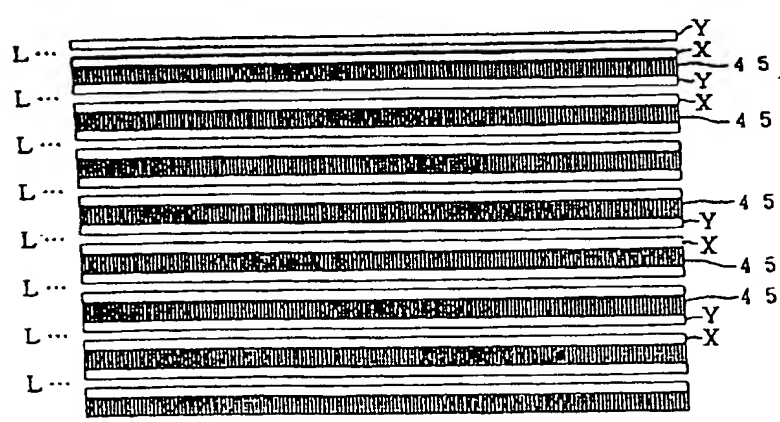


FIG. 4

FABRICATION OF THE FRONT SUBSTRATE

FIG. 4A

FIG. 4B

FIG. 4C

FIG. 4D

FIG. 4E

FIG. 4F

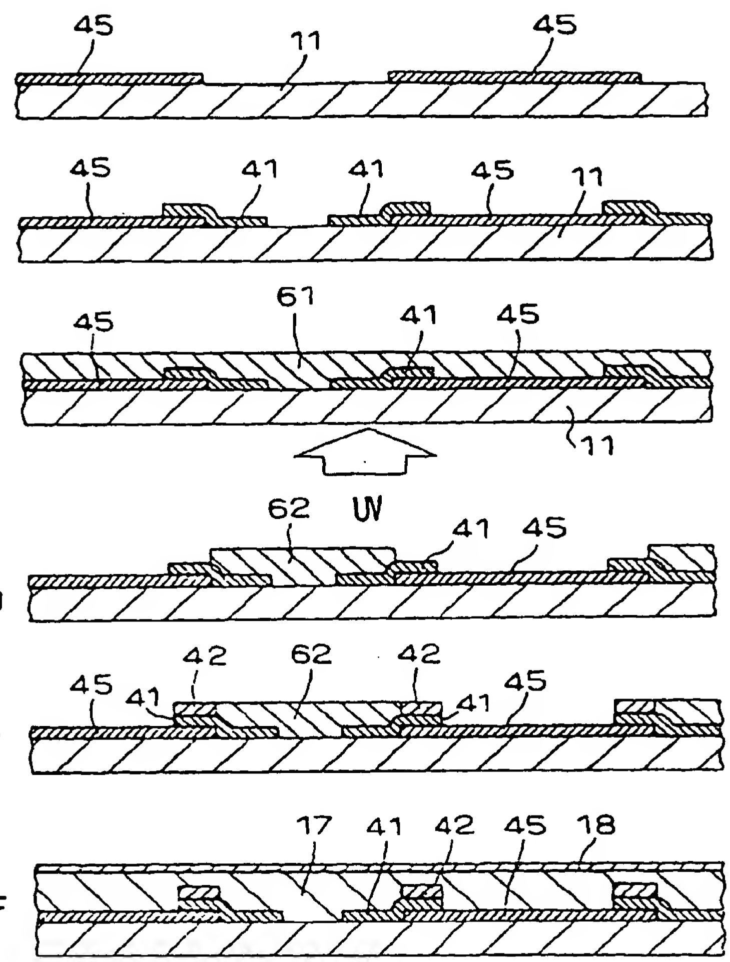


FIG. 5

SECOND EMBODIMENT

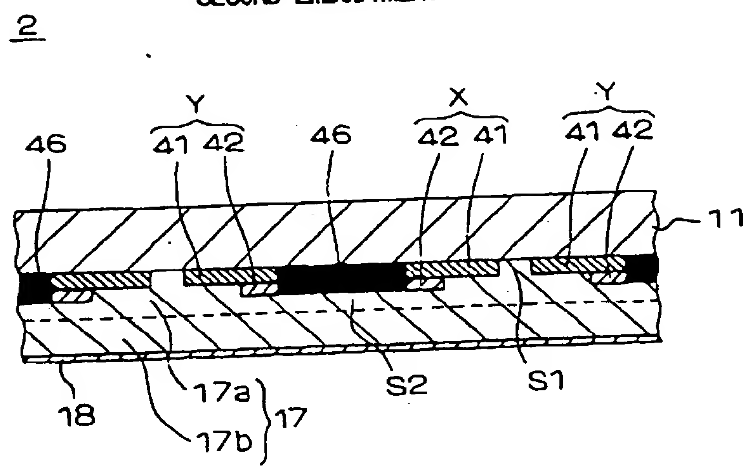


FIG. 6

THIRD EMBODIMENT

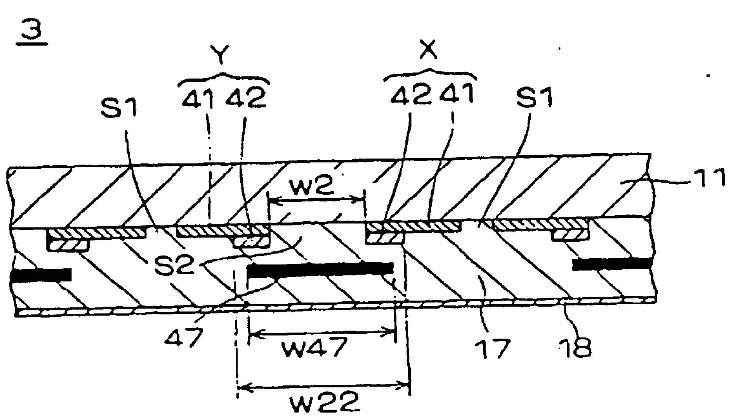


FIG. 7

FOURTH EMBODIMENT

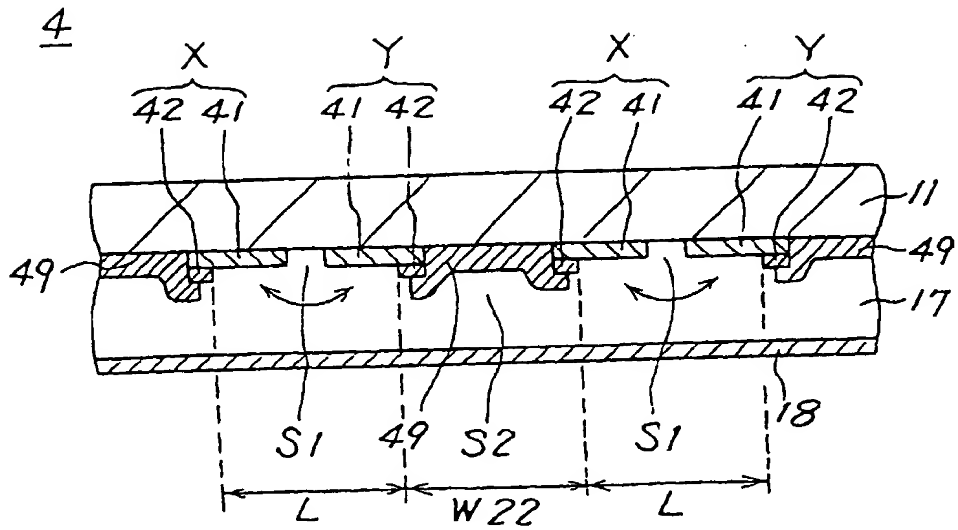


FIG. 8

FIFTH EMBODIMENT

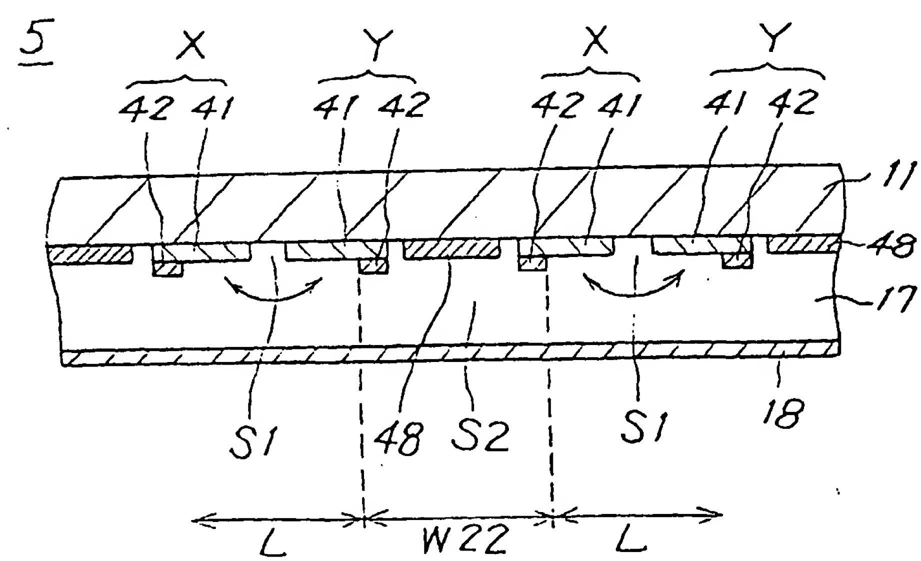


FIG. 9

FABRICATION OF THE FRONT SUBSTRATE

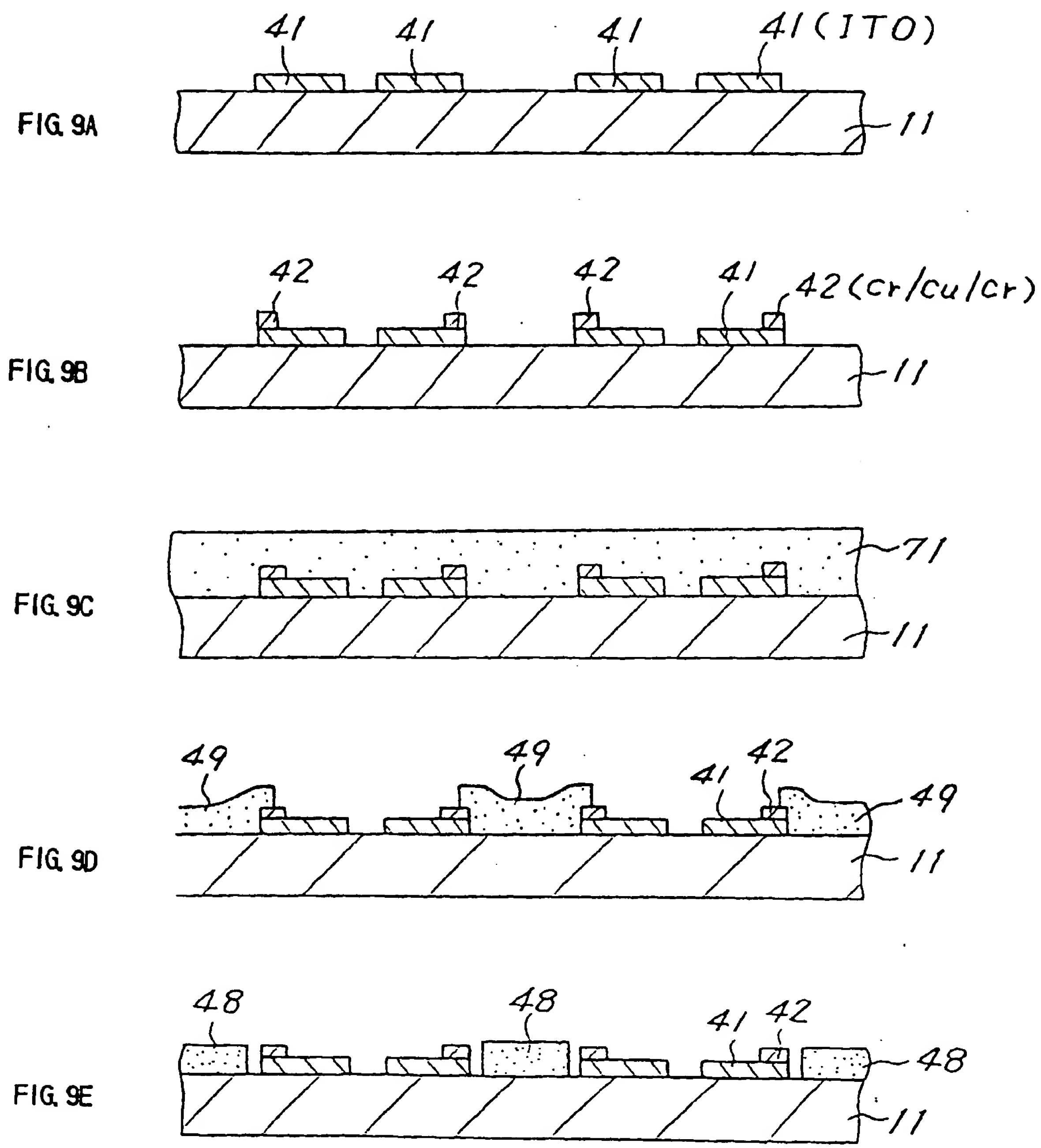


FIG. 10

FABRICATION OF THE FRONT SUBSTRATE

FIG. 10A

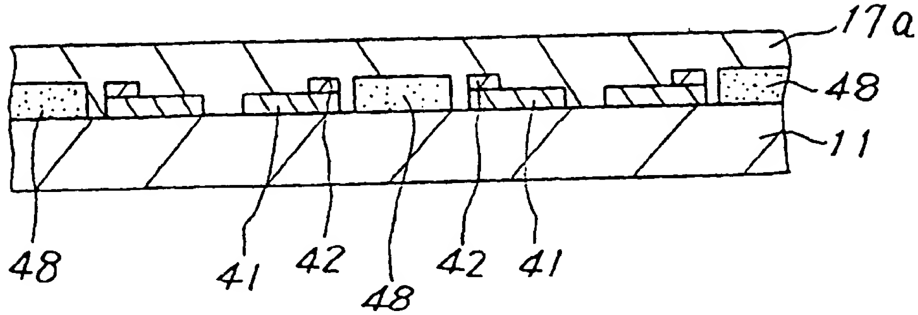


FIG. 10B

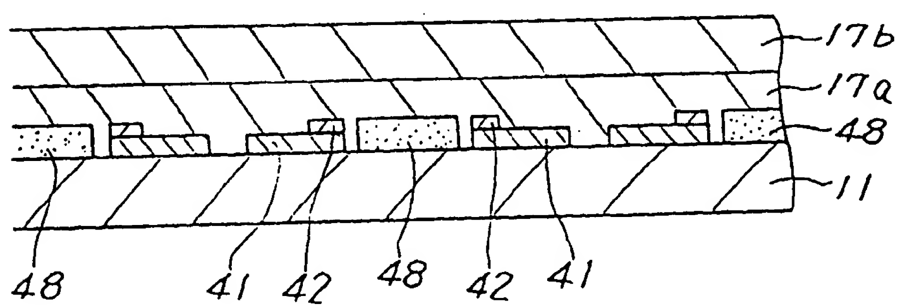


FIG. 10C

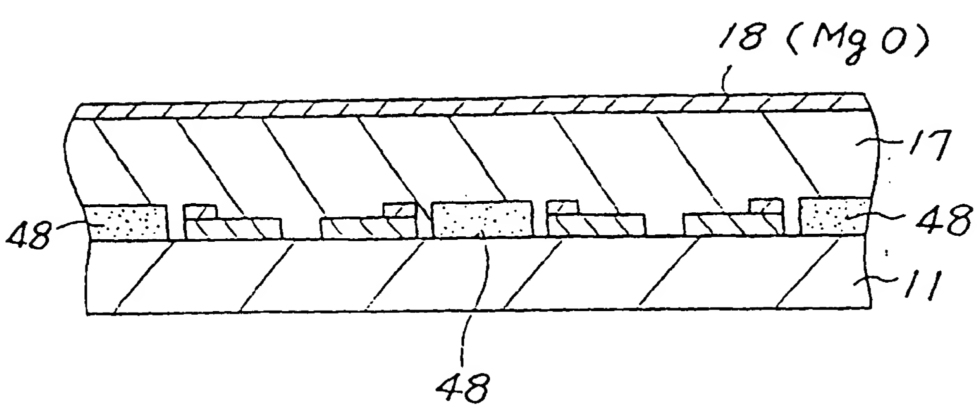


FIG.11

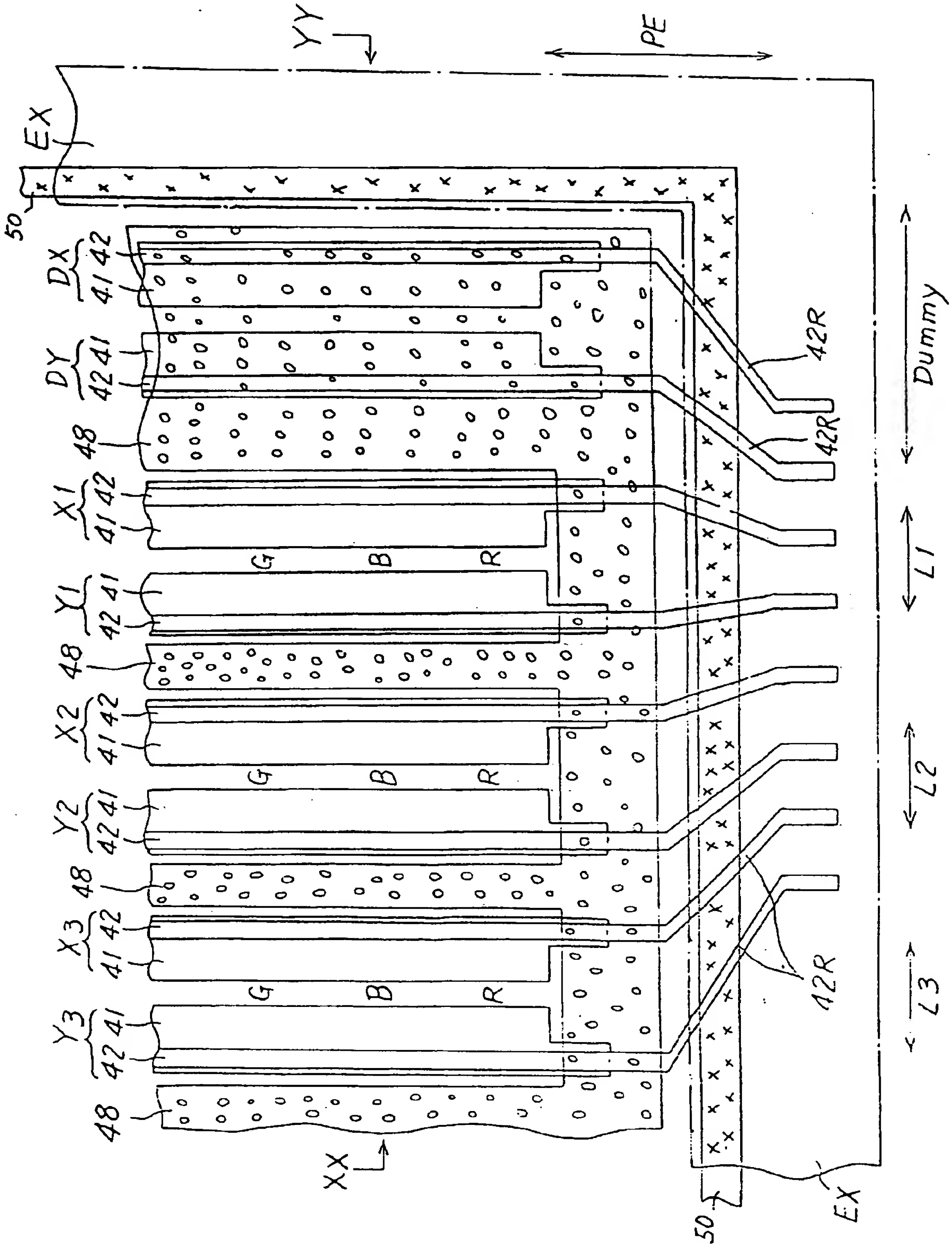

YY
PE
EX
50
DX
41 42
DY
42 41
48
X1
Y1
X2
Y2
X3
Y3
G
B
R
42R
Dummy
L1
L2
L3
XX

FIG. 12

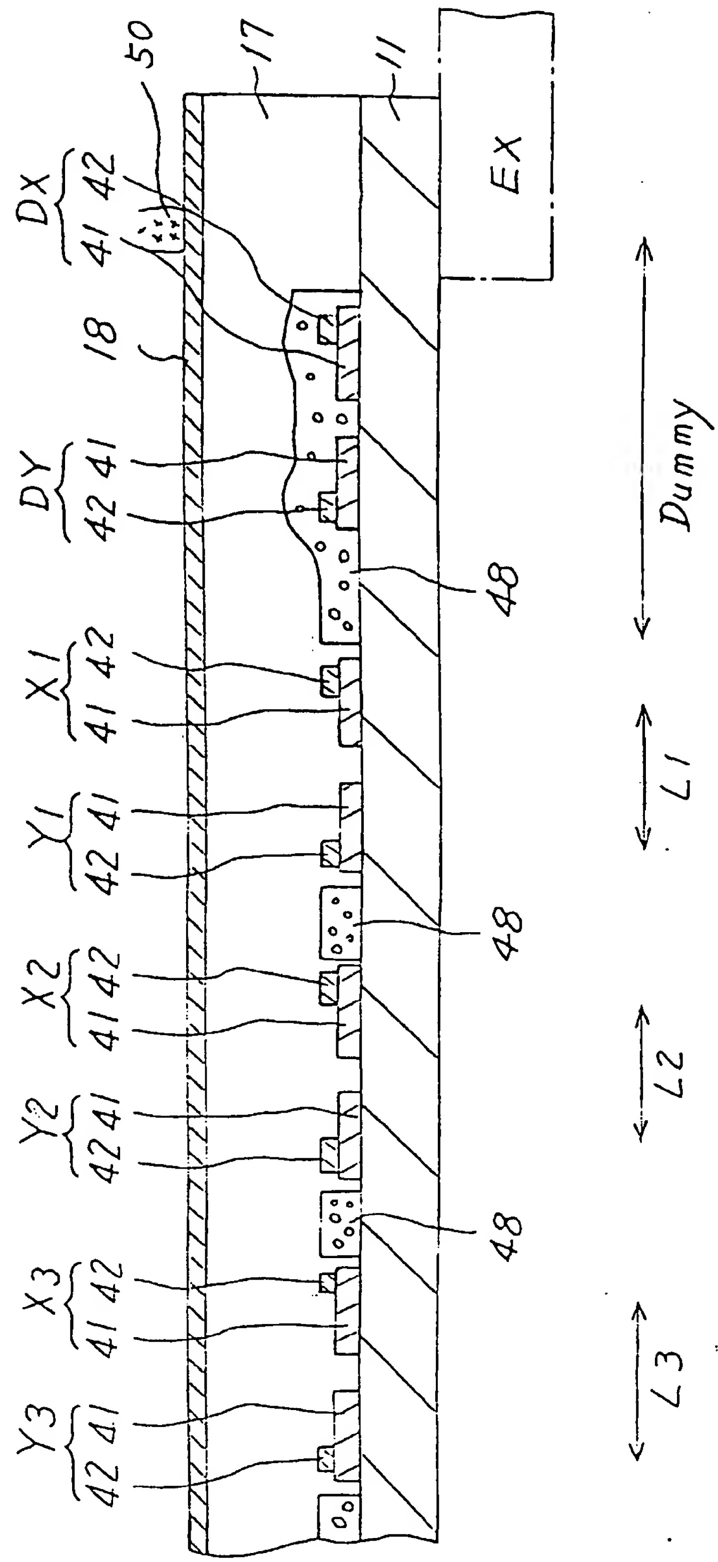

50
17
11
EX
DX
41 42
18
DY
42 41
48
X1
41 42
Y1
42 41
X2
41 42
Y2
42 41
X3
41 42
Y3
42 41
Dummy
L1
L2
L3

FIG. 13

MODIFICATION

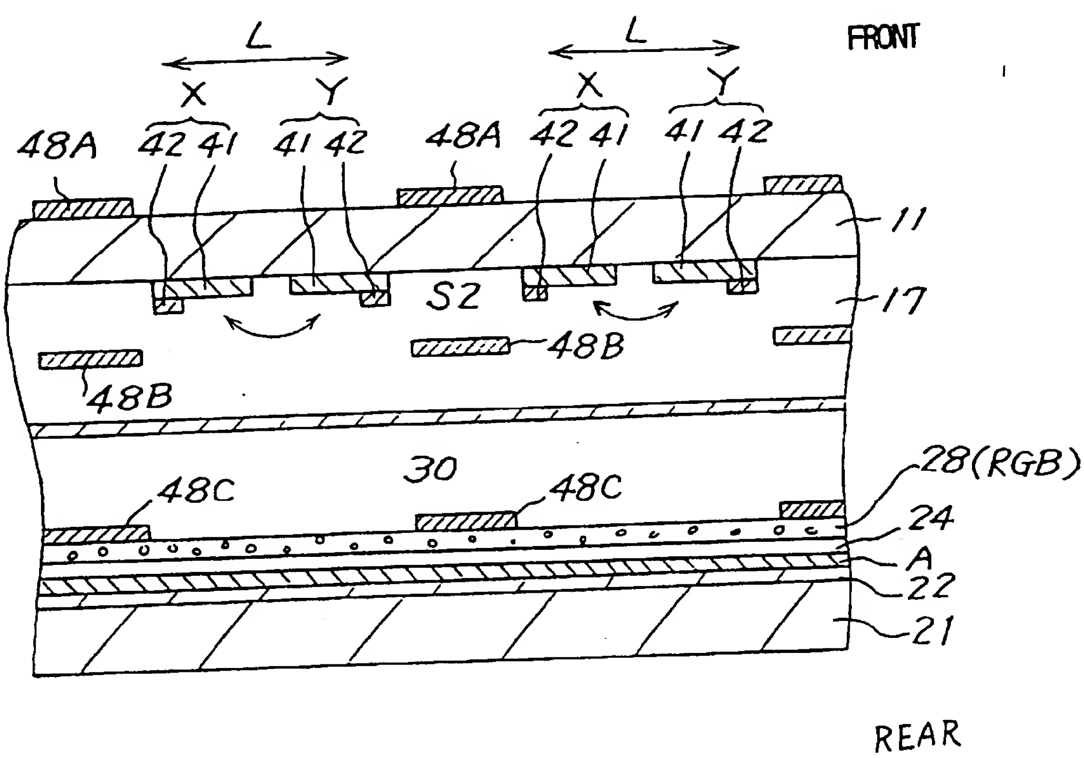
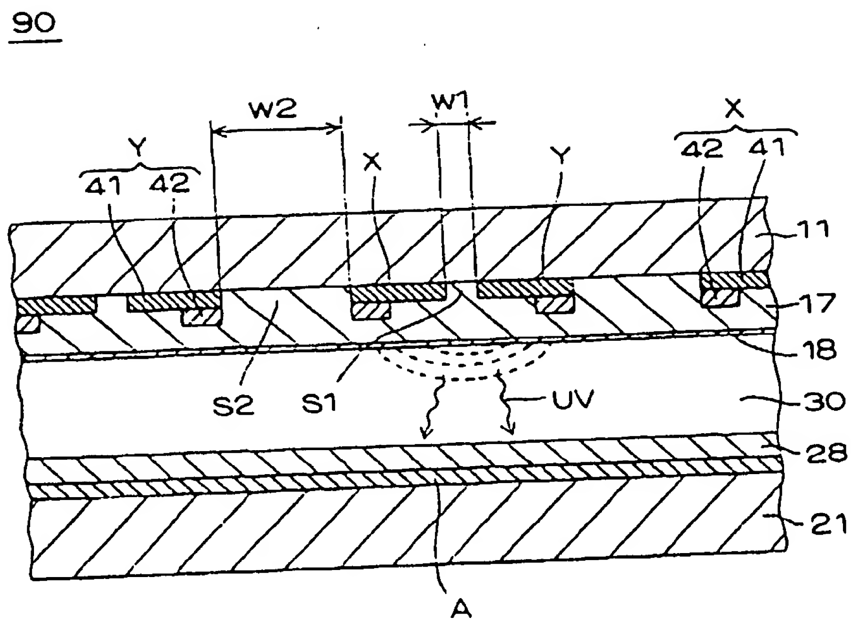


FIG. 14

PRIOR ART PDP



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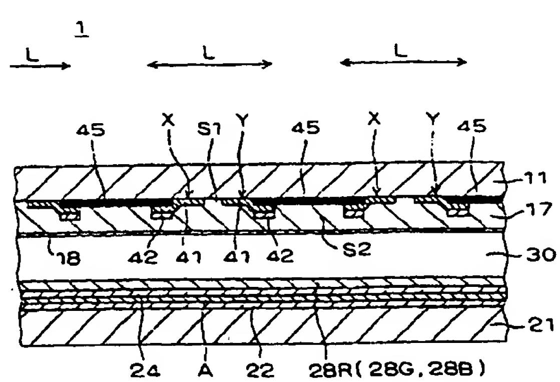
(54) A surface discharge plasma display panel and a manufacturing method therefor

(57) A surface discharge type plasma display panel (PDP) includes a pair of front and rear substrates (11, 21) with a discharge space (30) therebetween and a plurality of pair display electrodes on internal surface of either the front or rear substrate. The display electrodes extend along each display line L. The PDP further includes a light shielding film (45), extending in bands along the display line direction, formed on either internal or outer surfaces of the front substrate (11) to overlay each area S2 between the adjacent display lines L and extending between the display electrodes X and Y.

FIG. 2

FIRST EMBODIMENT



EP 0 762 463 A3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 96 30 6077

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	**Citation of document with indication, where appropriate, of relevant passages**	**Relevant to claim**	**CLASSIFICATION OF THE APPLICATION (Int.Cl.6)**
X	PATENT ABSTRACTS OF JAPAN vol. 017, no. 121 (E-1331), 12 March 1993 & JP 04 298936 A (NEC CORP), 22 October 1992 * abstract *	1	H01J17/49
X	PATENT ABSTRACTS OF JAPAN vol. 016, no. 275 (E-1219), 19 June 1992 & JP 04 067534 A (FUJITSU LTD), 3 March 1992 * abstract *	1,12	
A		20	
X	PATENT ABSTRACTS OF JAPAN vol. 009, no. 118 (E-316), 23 May 1985 & JP 60 009029 A (FUJITSU KK), 18 January 1985 * abstract *	1,3	
Y		16	
A		7,8	**TECHNICAL FIELDS SEARCHED (Int.Cl.6)**
Y	PATENT ABSTRACTS OF JAPAN vol. 005, no. 023 (E-045), 12 February 1981 & JP 55 150526 A (MATSUSHITA ELECTRONICS CORP), 22 November 1980 * abstract *	16	H01J
A		2,9-11, 13,14	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	4 September 1998	Noordman, F

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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